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A DIFFICULT PIECE OF BRIDGE ERECTION IN CONNECTION WITH TERMINAL IMPROVEMENTS OF THE NEW YORK CENTRAL & HUDSON RIVER R. R. CO.

By Frank C. Shepherd,* Assoc. M. Am. Soc. C. E.

The present approach to the Grand Central Station along Park Ave. is a four-track tunnel from 96th St. to the south side of 56th St. From here south there is an open cut with rising grade to 49th St., where the tracks are level with the intersecting streets. This incline takes up about one-third of Park Ave. and leaves a roadway on either side 42 ft. wide protected by stone retaining walls. The cross streets south of 56th St. are carried over the tracks by foot bridges only with stairways up at either side. The tunnel just north of 56th St. consists of a center tunnel of two tracks and two outside tunnels of one track each. A good idea of this can be obtained from Fig. 1. The retaining walls of the incline continue as side walls for the tunnel. The middle walls are of brick with steel columns encased in them carrying longitudinal beams at the top. Supported by the longitudinal beams and the retaining walls are 15 in. I-beams about 3 ft. on centers, with brick arches between them, on which is laid the street surface, as shown in Fig. 1. Between cross streets there is an opening in the roof of the old tunnel near the center of the block, about 150 × 20 ft. in size.

Under the new improvements the grade starts to depress at 57th St., and there is also a widening to ten tracks which is reached at the south side of 56th St. This depression continues the entire distance along Park Ave., so that the roadways now existing are to be restored on steel bridging at their present level, and the cross streets will be carried as highway instead of foot bridges, and at a normal grade from one side to the other. Along the line of the present retaining wall there will be a row of steel columns, but between 56th and 57th Sts., where the change is made from four to ten tracks, it was impossible to put in these columns on account of crossings and switches. It was decided here to carry the roadways by means of two large steel trusses of 150 ft. span and about 25 ft. center to center.

This article is written to illustrate the peculiar conditions met with and the methods employed in erecting and putting these trusses in their final position. After the street surface between 56th and 57th Sts. had been removed, the steel was brought in on cars and unloaded up through the opening in the roof of the old tunnel. The two trusses were then assembled and riveted together on the street, being blocked up under each panel point, as shown in Fig. 1, and all completed before the supporting columns were in place. In order to set these columns in place, pits about 6 ft. square were sunk between tracks, and excavations for the foundations all carried to solid rock at depths varying from 4 to 20 ft. below the present tracks. This was all done while traffic was going on, and as the tracks here are only a little over 15 ft. on centers, one can readily judge in what narrow quarters work was carried on, part of the middle walls being removed for this purpose.

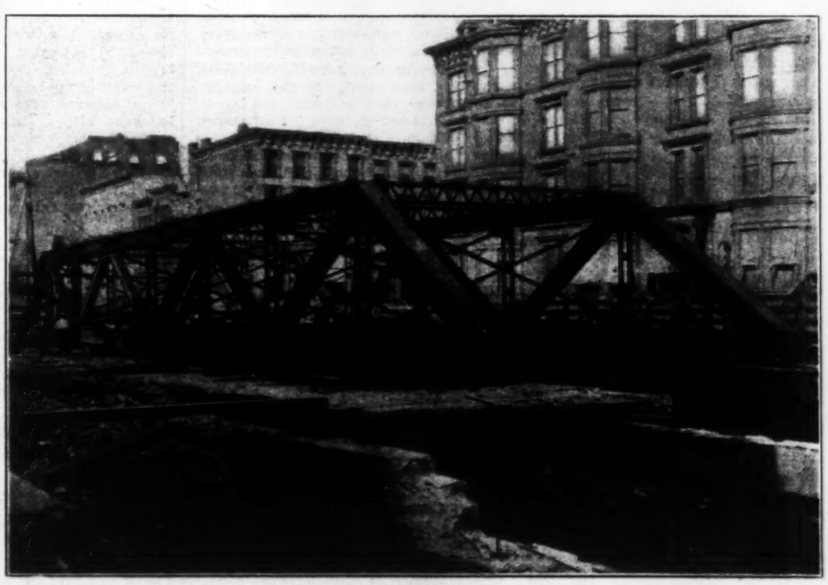


FIG. 1. WORK ON THE NEW TERMINALS OF THE NEW YORK CENTRAL & HUDSON RIVER R. R., ABOVE 42D ST., NEW YORK CITY; BRIDGE ERECTED ON THE OLD STREET LEVEL PREPARATORY TO LOWERING.

These pits being excavated to rock, concrete foundations were put in and the steel grillages set which carry the columns. Part of the roof and the longitudinal beams were next removed to allow placing the new columns. In placing the columns those at the north end were riveted directly to the truss, and wooden blocking placed between the base of the column and the grillage. The columns at the south end of the trusses carry the roller nest for expansion, and it was here necessary to place the columns on their grillages and put wooden blocking between the top of the column and the bottom of the truss, the columns being braced by timbers, Fig. 2. This left the two trusses blocked up about 4 ft. above their final position and carried on wooden blocking at each panel point and at the ends. The contractors then began taking down the roof and middle walls of the old tunnel. This, of course, had to be done at night and it was very slow work, one night some of the beams being forced apart by jacks and the brick arches dropped into cars, and the next night the beams removed on to cars, only about six hours' time being available to work. As fast as the roof was removed, the wooden blocking at each panel was replaced down to the top of the longitudinal beams. This is clearly shown in Fig. 2. After the roof had been entirely removed the middle walls were taken down with the exception of the post in this wall nearest to the ends of the trusses, this being used to assist in lowering the trusses into their final position. To keep these trusses in position they were at all times supported by shoring on either side against the top of the old retaining wall and at the north end by bracing against the middle wall and tying by steel wire with ratchets to old roof beams. The entire middle wall being removed, the next step of course, was that of lowering the trusses into their final position. To do this, framing was placed around the old posts mentioned above, which were left in, and on the top of that were placed 100-ton jacks, one at each corner of the truss. Blocking on the jacks was carried directly above to the hip plates at the end of the upper chord. One of these jacks in position with the framing above and below can be clearly seen in Fig. 3. When this was all ready, work was started about 4 o'clock one Sunday morning in August and strains were taken by these jacks. The trusses were then lowered a few inches at a time, first at one jack and then at another in rotation. After a strain had been taken a large block was removed and several smaller ones put in its place which were then taken out one at a time as the

*Resident Engineer Manhattan District, Terminal Engineer's Office N. Y. C. & H. R. R. R., Grand Central Palace, New York City.

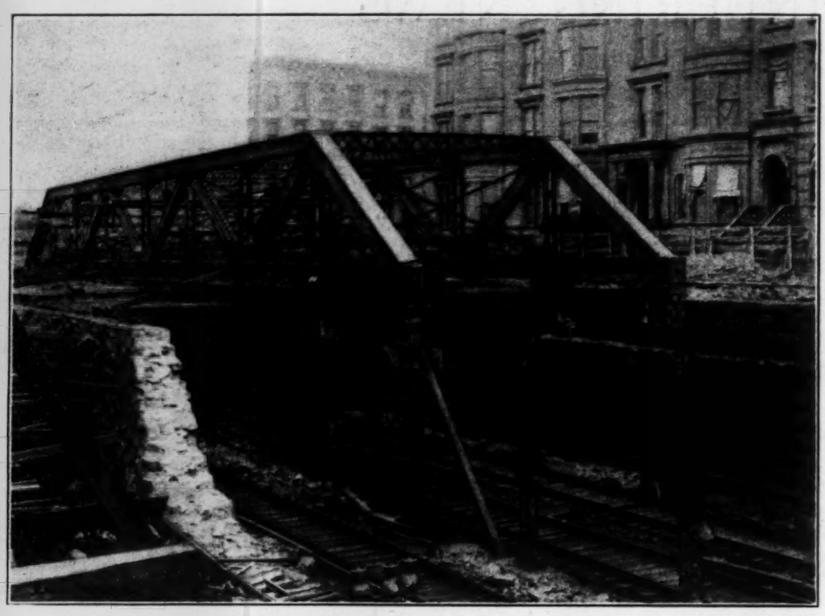


FIG. 2. BRIDGE SUPPORTED AND BRACED, READY FOR LOWERING.

truss was lowered. This was done so that in case anything gave way there would be a very slight drop in the truss at any point and thus save any chance of accident. At the same time the braces mentioned above were watched and the wedges at the wall ends loosened as the trusses came down to final position. The lowering was all done in seven hours and when the north end of the truss came to a bearing, the columns were found to fit exactly on their grillages, and at the south end everything came into final position, as shown in Fig. 3.

The work of erecting and lowering the trusses into place was done by Terry & Tench, who are the sub-contractors for the O'Rourke Engineering Construction Co., who have the entire contract for the Grand Central yard improvements.

During the entire work trains at an average of over 1,000 per day were continually passing under these trusses and there were no delays at this point during the entire work.

THE GRAVEHALS TUNNEL ON THE CHRISTIANIA-BERGEN RAILWAY IN NORWAY.

One of the most interesting tasks of railway construction that has been accomplished in recent years is the new line connecting the cities of Christiania and Bergen in Norway. Besides the difficulties of constructing a large portion of the line in a region of eternal snow, the construction work involved the building of a tunnel which ranks in length among the few long railway tunnels of the world. Owing to obvious reasons, very little definite information has gotten into print regarding this tunnel, and we, therefore, take interest in reprinting the following unique account of the work from our English contemporary, "Public Works," of Oct. 15, 1904:

In about the middle of the decade 1890-1900, the Norwegian Storthing decided on the building of a main railway line to connect Christiania and Bergen—the two principal towns of Norway.

Owing to the topographic nature of the country and the obstacles it presented in the way of railway building, this work had thus been shirked till toward the beginning of the present century. All railway building in Norway is expensive and difficult on account of the northern latitude as well as the mountainous character of the country. This applies especially to the Christiania-Bergen line, which, moreover, at its highest point reaches an altitude above the sea level, double that of any other Norwegian railroad (i. e., 4,100 ft.), and for a length of no less than 40 miles runs through the regions of eternal snows, above all vegetation, through a desert of rock and ice. An altitude, in Norway, of 4,000 ft. above water line corresponds, because of the northern latitude of the country, to nearly double the same height in Switzerland—a fact to be borne well in mind when estimating the obstacles in the way of railroad building during a long, dark winter, when continual snowstorms are the order of the day from month's beginning to end.

The hardest task on this line has been the Gravehals tunnel—a tunnel 5,300 m. (about 3.3 miles) long, situated on the western slopes of the middle mountain region, at a distance of 30 miles from the nearest point of civilization, viz., Voss, the terminus of the earlier completed Bergen-Voss section of the line.

The Gravehals tunnel ranks as the seventh or eighth of the large tunnels of the world, but with regard to isolated and desolate position it takes the lead by a long way. Adding hereto the exceptional hardness of the rock, a quartzy granite or gneiss, the tunnel may well be said to be unique of its kind, and, from a technical point of view, not to be judged by the same criterion as the other notable tunnels of the world. The height of the mountain traversed by the tunnel is about 2,000 ft. Any great heat inside was thus not anticipated, and the temperature turned out even lower than expected, and never exceeded 8-10° C., which, however, must be attributed partly to the low temperature of the air pumped into the tunnel. Neither did water cause much trouble, thanks to the hard and uncut rock, although the tunnel runs right under two mountain lakes at a vertical distance of about 800 ft. At both ends of the tunnel fairly large waterfalls from the adjacent higher situated mountain regions furnished motive power for the machinery. At the start it was feared that the formation of ice would take place in the tubes and turbines owing to the low temperature of the water during the winter (about ¼° C.)—difficulties which, however, were overcome by ample covering of conduits and supply pipes.

The contract for the building of the Gravehals tunnel was, in the autumn of 1895, conceded to the civil engineering firm and contractors, Messrs. Ström & Horn, in competition with a number of native and foreign firms, and the work was started during the same autumn.

Only small progress could be made in the first year, a 20-mile transport road at the west end having first to be constructed, and necessary dwelling houses for staff and workmen, together with shops for the machinery, etc., to be erected. The machinery at the west end of the tunnel was installed and machine boring commenced in January, 1897. From the beginning an instalment of machinery was only projected for the west end of the tunnel in the belief that the time allowed in the contract (to 1903) would allow of taking the tunnel from the west by hand boring. It was, however, soon obvious, that owing to the hardness of the rock the advance by hand boring was quite insufficient (only averaging 9½ m. per month), necessitating in the winter of 1898-99 a complete instalment of machinery at the east end as well, the machine drilling starting at that side in June, 1900, nearly 2½ years later than at the west end.

The machine drilling in this tunnel is of special interest on account of the application of different systems at each end (similar to the operation in the Arlberg tunnel, Switzerland). At the west end hydraulic drilling machines (Brandt's system) were used, while the drilling at the east end was done by pneumatic machines (from Frölich & Klüpfel, Barmen). The instalment of machinery at the west end consisted of two Gerard turbines of 230 HP. together, working (1) the hydraulic pumps for supplying water to the Brandt machines (about 70 HP.), (2) three centrifugal ventilators for blowing air into the tunnel (about 60 HP.), and (3) an electric dynamo for providing light for the camp and for transferring power to the workshops for repairs, the latter situated close to the mouth of the tunnel, while the power station lies near a waterfall about 400 m. distant from the tunnel.

With the hydraulic pumps connected to an accumulator a water pressure of 70 to 80 atmospheres was obtained, giving, from the unavoidable loss of water through the long tubing, a working pressure of about 60 atmospheres on the drill machines in the tunnel.

The three ventilators, placed the one behind the other (coupled on pressure) delivered about 0.5 cu. m. of air per second. The ventilation ducts having, however, been chosen of somewhat small size (30 cm. diameter), it became desirable, as the heading advanced, to improve the access of air by placing injectors inside the air pipes. These injectors were worked by water taken from the hydraulic main at the side, receptacles for collecting the water when running out again from the air tubes being placed at the front of each injector. These injectors, three in number, proved most effective. They were only put in action during the loading of rock after each blasting, when the drill machines were at rest and required no water.

The air being renewed in this way after each blasting the injectors were closed, the three ventilators at the

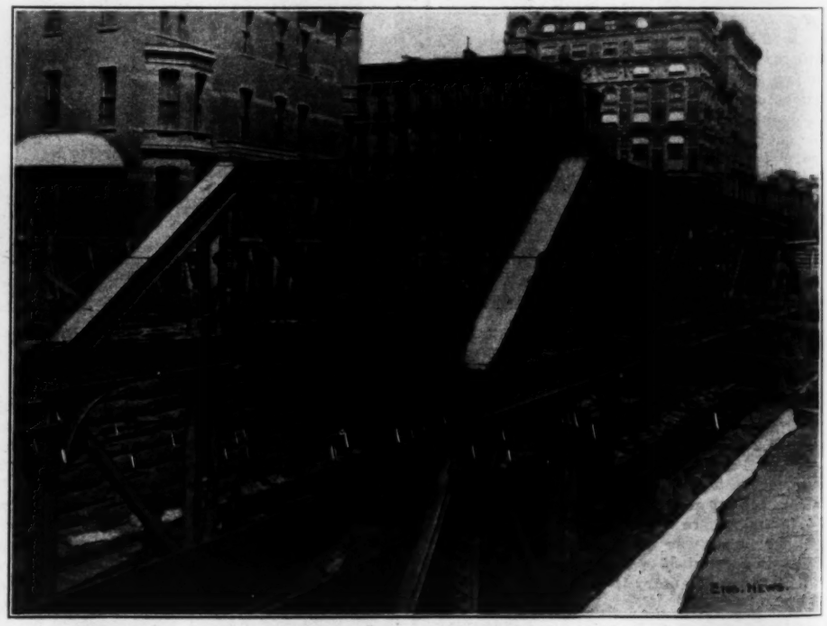


FIG. 3. BRIDGE RESTING UPON ITS SUPPORTING PIERS; 100-TON JACKS STILL IN PLACE.

wer station providing a sufficient supply of air during e drilling.

The shops for repairs were from the first furnished with e necessary lathes, special machine tools for cutting e drills for the Brandt machines, drilling machines, d also a metal foundry plant, as on account of the lusion of the locality it became necessary to effect all pairs on the spot as far as possible, and to make all lls required for the machines.

The Brandt machines are not provided with ordinary lls, but with steel tubes of about 2½ ins. diameter, t into lengths screwed at the ends for jointing, and vided at the point with two to four strong claws. The ll does not act by percussion, but is forced by the achine with a pressure of about 14 tons against the ck and slowly turned round at the rate of about six volutions per minute. In this way the rock is splintered o small pieces or shavings, which are washed out of e drill hole by the waste water from the machines pourg through the hollow drill shaft.

Dynamite, which freezes at a temperature of 6-8° C., quires to be thawed in these regions even in the midst summer. This was effected on the Gravehals tunnel by placing the frozen dynamite in closed boxes or lockers, the air being heated by small electric glow lamps to a temperature of 30-40° C.—a very safe and practical method.

At the east end of the tunnel the work was carried on with pneumatic machines from June, 1899, as already stated. The compressed air required was furnished by two air compressors of 45 HP. each, of the Buckhardt & Weiss type, installed in a power station close to the mouth of the tunnel, the same building also housing a centrifugal ventilator and repair shops. The reason why only one ventilator was required at this end was partly due to the later start at the east, only one-third of the whole heading being taken from this end, and partly also because the compressed air from the machines assisted the ventilation to a considerable extent.

The waterfall, furnishing power at the east end, is situated about 1¼ miles from the mouth of the tunnel, power transmission being effected by the aid of a high tension electric cable conveying current at 2,000 volts from the dynamos at the power station to a 125-HP. electric motor placed in the machinery building at the mouth of the tunnel.

The pneumatic rock drilling machines employed differ but slightly from those of the Ingersoll-Sergeant type.

The results of the machine drilling in the heading are given in Table I.

It should be noted that while comprising the work done at the west end for the whole period of five years, this table includes only work for 10½ of the 37 months during which machine boring took place at the east end. As, however, the average monthly advance for these 10½ months corresponds closely to the average advance per month for the whole period (being 38 m. per month for 10½ months, against 38.64 m. for the whole period of 37 months), the table gives a fairly correct return for work at the east end of the tunnel.

In order to arrive at a fair estimate by comparing the results as shown in the table, the following information is furnished:

(1) The rock at the east end was throughout less hard and consequently more easy to drill than at the west end.

(2) The dimensions of the heading at the east were only about 2 m. × 2 m. = 4 sq. m.,² but at the west end about 1.8 m. × 2.6 m. = 4.68 sq. m. While, however, the advance per 24 hours at the east end only shows 1.49 m., against 1.97 m. at the west end, the comparison as far as advance in the heading is concerned shows decidedly in favor of the Brandt hydraulic machines.

A somewhat better advance could undoubtedly have been obtained—applicable equally to both systems—had it been found remunerative to incur the extra expense of forcing the rate of working, but more than 20% above the given figures would hardly have been reached in the Gravehalsen hard rock, even by forcing the work to the utmost. An advance by the Brandt machines of 5 m. or more per 24 hours, as in the Simplon tunnel, would have been an impossibility in the Gravehalsen rock.

But although the Brandt machines have thus shown their superiority as regards rapidity of operation, it might be supposed—and has been asserted—that the cost of the plant and the working expenses of the drills would be heavier. As regards the former, however, the difference, if any, between the two systems is very little. With the heading advance, as above given, the consumption of power by the machines of both kinds was about equal, perhaps somewhat larger for the pneumatic drills, but on the other hand less power was required for ventilation in the case of the pneumatic drills at the east end.

Thus the cost of operating the plant with all power and auxiliary machinery has been fairly equal. As for the drilling machines themselves the cost of the hydraulic type was nearly three times that of the pneumatic type, but then only four Brandt machines (of which two at a time were at work in the heading) were worn out at Gravehals during the whole period, while for the same length of heading probably twelve pneumatic (four employed in the heading at a time) would have been used up. One advantage, however, the air drills must be credited with, is that they are also serviceable for extension work, if such must necessarily be done by machinery; but in Norway at least this advantage is rather illusory, for extension work is there done more cheaply by hand labor. Moreover, the time allowance in reality only depends upon the heading advance, and the unlimited number of attacking points allows the extension work to follow immediately upon the heading, even if this be worked by machine and the former by hand. As regards Gravehals, however, this argument does not hold good, the difficulty of procuring a sufficient number of efficient hands, even at very high wages, having retarded the work of extension to such a degree that this part of the work will not be completed till 2½ years after the cutting through of the mountain. Under these circumstances the pneumatic drills at the east end have, to a large extent, been used for extension work at an increased cost of 20% compared with hand drilling.

In spite of the 33% quicker advance by the hydraulic method, the difference of cost between the two systems is not so great as might be expected, as is shown in Table II, comprising all expenses connected with the drilling, blasting, loading and transport of rock, but excluding the original cost of plant and administration.

TABLE II.—Cost of Machine Drilling at the Gravehals Tunnel, Norway, Per Meter Run of Heading in Kroner (18 Kroner = £1).

	Position and kind of machine. West end, hydraulic.	East end, pneumatic.
Dynamite, caps, fuses	57.64	57.82
Lubricants and packings for machines	1.27	.....
Consumption of drill steel	7.68	4.19
Sharpening and grinding of drills (including coal)	5.74	7.16
Making new drills and recutting old ditto	5.29	....
New reserve parts for machinery	1.99	2.03
Wages paid for drilling of heading	27.29	41.84
Expenses of repair shops	23.16	7.75
Cost of working power machinery and pumps	8.70	13.42
Sundries	0.46	0.43
Loading, carting and discharging rock (including repairs of rails, wagons, etc.)	29.15	20.43
Total	170.37	155.07
Earnings for 10 hours for drill workers in the heading	5.52	7.00

The following are explanatory notes relative to Table II:

(1) The dynamite is calculated at a price of 2 kr. per kilogram. Contrary to all expectation the consumption of dynamite was not less by the pneumatic than by the hydraulic process.

(2) As regards lubricants, the air-driven machines were only used with refuse oil from the power machinery.

(3) Only few reserve parts for machinery were bought from without, the repair shops having supplied practically all necessary wants.

(4) Wages paid for the drilling of heading were considerably higher at the east end, owing to the slower advance by the air-driven machines (even not counting with the higher wage per hour). The number of machine attendants at each end was four men working eight hours per shift.

(5) Maintenance of the hydraulic machines was found to be considerably more expensive than that of the pneumatic.

(6) The cost of working power machinery at the east end being nearly 5 kr. per meter dearer than at the west end was, in addition to the slow advance at the east, due to there being at this end of the tunnel two power stations, a primary one at the waterfall, 2 kilometers from the tunnel, and a secondary one at the mouth of the tunnel.

(7) The reason for loading, carting and similar work being less costly at the east end is, in the first place, attributable to the smaller profile of the heading at that end, but partly also to the greater facility of loading the blasted masses at the air-driven machines. These being mounted on light, vertical pillars, could be transported across the heaps of rock and re-started at work in a much shorter time than the handling of the hydraulic machines permitted. Thus, the loading of rock at the air-driven machines took place almost independently of the drilling, while the heavy hydraulic machines had to be shifted out and in upon a specially constructed rail wagon, and could not be replaced at the point of attack before all blasted masses had been loaded and removed. This again necessitated heavier and consequently more expensive loading at the hydraulic machines than at the pneumatic, where the greater part of the rock could be loaded at leisure after the machines had resumed work. This explains why the time of loading, as shown in Table I., was only 2 hrs. 11 mins. at the east end, against 3 hrs. 39 mins. at the west end, per running meter.

(8) As shown in Table II, the earnings of the drill hands were higher at the east end, giving a proportional increase in the cost of the heading. This was, however, due to local circumstances and cannot be laid to the charge of the drill system. The difference of cost between the two headings is, according to the table, 15.30 kr. per run-meter. Supposing the scale of wages to be the same for the drill workers at both ends of the tunnel, the air-drill heading would have been 24.7 kr. per meter run cheaper than the hydraulic. But then it must be borne in mind that the latter heading has a dimension of about 4.70 sq. m. against the former of 4.00 sq. m., giving a lower price per cu. m. for the hydraulically driven heading.

The cutting through of the Gravehalsen rock was completed on July 4, 1902—nearly 5½ years after the hydraulic machines started work at the west end and three years after commencement by the air-driven machines at the east end.

During the cutting of the heading two stoppages of some length took place—one of two months' duration, owing to water famine at the west end in the exceptionally dry spring of 1900, another almost equally long in March, 1901, caused by an avalanche of snow at the west end, smashing in a wall and the roof of the turbine house, filling it with snow and demolishing the power plant inside the building. In other respects the work has proceeded regularly, though under great difficulties in the way of procuring skilled workmen, and the continued struggle to keep the most scanty communications open with the outer world during snowstorms, continuing with short interruptions for two months at a time.

The extension work in the tunnel will be finished about the end of 1904, and in the summer of 1905 the first engine is expected to pass the tunnel on its way up to Taugevand, which, as already stated, is the highest point on the line, about 4,100 ft. above sea level.

TABLE I.—Record of Machine Drilling in the Gravehals Tunnel, Norway.

Position and kind of Machine.	Diameter of Drill holes.	Per Metre run of Heading. Drilling Time.	Loading Time.	Total Time for Attack.	Number of Drills.	Dynamite	Length of Drill hole.	Advance per Attack.	Advance per 24 hours.	Total number of working days of 24 hours.
	m/m.	h. m.	h. m.	h. m.		Kilograms.	metres.	metres.	metres.	
West end (hydraulic)	63	8 32	3 39	12 11	49.45	26.77	12.16	1.46	1.97	1658.1
East end (pneumatic)	30	13 55	2 11	16 6	49.45	28.00	15.00	0.90	1.49	267.7

METHODS AND COST OF BLASTING AND HANDLING BOULDERS.

By Daniel J. Hauer.*

In considering the cost of rock excavation, but little attention has been given to the economical handling and breaking up of boulders. Very few records seem to have been kept as to the cost of such work, and although it is difficult for this reason, to set a fair price for breaking up and handling boulders of various sizes, yet the cost of this detail work enters very materially into the cost of solid rock excavation. The subject is worthy of close and prolonged study.

In these papers it is proposed to set forth the different modes or methods of handling and breaking up both large and small boulders; giving some data as to the costs of doing this class of work, and commenting upon the subject so as to point out the proper use of each method, and to prevent wheresoever possible the waste of money in doing this class of work. Although it is, of course, necessary to break up a boulder before it can be handled, yet, in as much as the size to which the rock is to be broken, depends upon the method the stone is to be handled, we will first discuss the handling of boulders. It is earnestly hoped that a discussion of this subject may be a help to those engaged in rock excavating, and all them in giving the matter the attention it merits.

In discussing details of construction work, or excavation, we may first consider under this or, in fact, under any head, the overshadowing factor that enters first and last into all costs, namely the foreman. Every contractor has had the sad experience of seeing work cost him far more when handled by a foreman than it would have cost if it had been possible for him to have directed his forces himself. On moderate size jobs, at times, personal supervision can be given each foreman, but on work of any magnitude, a contractor is almost entirely at the mercy of his foreman as regards the detail handling of his work. It is to be regretted that the average foreman cares but little as to the most economical method of handling work, but is firmly convinced that his way is the proper one, and a large number of

1739 North Broadway, Baltimore, Md.

foremen firmly believe that no one can teach them anything regarding their work. Should one be discharged, his successor is more than likely to pursue a similar course, yet by a careful system of culling and weeding out of incompetent foremen, a contractor can in the course of some years surround himself with a number of fairly competent men. Then by using tact and judgment, these men can gradually be taught new methods, and many of their old ways of work be improved upon. Imparting knowledge to foremen is, at best, a difficult task, but knowledge is of little value unless it can reach the men who are actually doing the work.

This task of instructing men is frequently the price a contractor must pay for success, for although one may make a profit on contracts with incompetent foremen, or loose methods of doing work, yet success has not really been achieved unless the greatest profit possible has been derived from the job. A contractor who is able to surround himself with good foremen, who will carry out instructions and work towards the end of true economy, has gone a long way towards success, no matter what the undertaking. Another factor and valuable aid in deciding on all modes of doing construction work is the continual use of the minute hand of a watch.

The methods of handling boulders after they are broken up, are by (1) steam shovels, (2) derricks, (3) cable ways, (4) sleds or lizards, (5) carts or cars, and (6) wagons.

STEAM SHOVELS.

(1) In making excavations with steam shovels, solid rock is frequently encountered, and the shovel is, in most cases, compelled to excavate its way through this material. When moving solid rock with a steam shovel, the excavation can generally be done much faster with the shovel than it can be by men and teams, but the cost is apt to be more, as a more expensive outfit is used and higher salaried men are employed on shovel work. Then, too, the wear and tear on the shovel is extremely severe, and at times a shovel will be so badly racked after making a large rock cut, that but little satisfactory work can be done by it afterwards. For these reasons contractors ask a higher price for solid rock excavation made with steam shovels. The writer at one time moved 15,000 cubic yards of solid rock, working day and night shifts, per month, for four successive months, with one shovel. This was certainly quicker than men and teams could have handled it. A small shovel cannot work as advantageously as a large size shovel in solid rock.

When rock is encountered in steam shovel work, the ordinary digging dipper should be replaced with a rock dipper, which is more heavily constructed, is not so deep, and is larger in diameter, thus allowing larger boulders to pass through it. The handling of such boulders adds but little to the cost of the excavation, as the only drawback is the care and time necessary in picking them up and dumping them into the cars. It is a difficult matter to keep such cost data. Boulders that will not pass through the dipper, can have chains fastened around them by the pitmen, and then loaded by the shovel into cars. Boulders measuring from ½ to 1 cu. yd. can be handled cheaply in this way. Chains with two hooks should be used, one hook being used in fastening the chain around the rock, and the other in attaching it to a chain already made fast to the dipper arm. When a large number of boulders are to be loaded, one chain can be attached to a tooth of the dipper while another can be fastened around the dipper arm directly behind the dipper. In this way two small boulders can be handled at one time, while when it is necessary to pick up a large boulder the chain around the dipper arm should be used. The extra cost of handling this size (½ to 1 cu. yd.) by this method is but little, as the pitmen can get the boulders ready to be picked up, while the shovel is loading the fine stuff and smaller boulders, or while the shovel is idle. The major part of the extra costs consists in the chains necessary to do the work.

Boulders measuring from 1 to 3 cubic yards can, as a rule, be picked up better by a chain and a pair of grabs. The extra cost here will consist of the additional time consumed and the expense of a hand driller to "dog" the stone. His wages will be from $1.50 to $2.50 per day, according to the locality in which work is being done. It is seldom safe to attempt to pick up boulders containing over 3 cu. yds., unless the shovel is a very large one, and even then the question as to the weight-carrying capacity of the cars, being used, has to be considered. The writer once loaded with a 65-ton shovel a granite boulder containing a little over 4 cu. yds., the estimated weight of the block of stone being about 15,000 pounds, but he never wishes to repeat the performance as the chance of accident is too great.

When proper arrangements are made to handle boulders with a steam shovel, but little dynamite is needed to break them up, as only the largest boulders, thrown out by a blast, cannot be loaded by the shovel.

Dynamite should be used on these, and owing to the close proximity of the shovel, "mud capping" should be resorted to, as to place the charge under the boulder or in a "block hole," will run too much chance of injuring the shovel by throwing large spalls on it. As the boulders "mud capped" will always be large ones, high power dynamite (60% or over) will be needed to do this work. Another reason for "mud capping" will be that the shovel will not be able to operate until these large boulders are disposed of, and both time and money will be saved by this method.

At times a "stone boat" will be found useful, as the pitmen can load it with boulders that have been scattered out of the range of the shovel, and the shovel can then dump the load. The size of the boulders loaded by a shovel, must to some extent be governed by the style of cars being used, or else the cost of unloading may more than equal the amount of explosives saved. Extremely large boulders cannot be cheaply handled on flat cars, and, of course, only boulders that will pass through the dumping opening can be loaded on the patent dump cars, but by removing the sides of the two-way pivot dump cars, almost any size boulder can be dumped from them. Great care must always be exercised in dumping boulders from trestles, or great damage may be done to the structure.

When solid rock lies only in the bottom of the cuts, it is less costly to take the machine over the rock than to excavate it with the shovel; we then come to the consideration of other methods of handling boulders. Derricks of various types can be used for this work.

DERRICKS.

(2) The writer once had built a derrick on an ordinary standard gage flat car. Instead of a mast, an A-frame was used to operate a 30-foot boom. A double-drum reversible hoisting engine was mounted on the other end of the car, and light jack-arms were used to brace the car. This derrick car was operated by two men, an engineer and a fireman. Boulders weighing as much as 5 tons were handled. This machine was built at a total cost of $2,000, including car and engine, the latter cost $1,000. Although this derrick did not handle rock as rapidly as a steam shovel, yet its work was more economical, and satisfactory results were obtained. With "stone boats," chains and grabs, the handling of boulders with this derrick was quite similar to such work done by a steam shovel.

Ordinary hand power, horse power and steam derricks can be used to advantage in handling boulders, and in some classes of work money is frequently lost by contractors not providing themselves with the proper derricks. In borrow pits, on side hill cuts on railroads and similar places show a ready use for different style derricks. No rule can be set down for styles and uses of derricks, but the conditions surrounding the work in hand must govern the selection of the derricks. To handle stone successfully with derricks, it is necessary to have several chains, sets of grabs and stone boats.

When only a few large boulders have to be handled from time to time, and loaded into a small dump car or wagon, a three-legged derrick and a triplex block can be used very economically. The derrick can be set up quickly over the boulder, and with the block the stone can be picked up and the car or wagon then run under the suspended boulder and the load let down. This will be found less expensive than breaking the boulder up so it can be loaded by hand.

When a steam derrick has to be frequently moved short distances, it will be found expedient to mount both engine and derrick on a low, broad gage (10 feet) car, and move the car from place to place on a track, which can be built of wood. Uses for a car of this description can be found in both railroad and canal construction and boulders weighing five tons can be handled.

In handling boulders with derricks "mud capping" to break up boulders should never be resorted to, as there will always be time to do the necessary drilling to block the rock. At times the charge may be placed under the stone, but owing to the great chance of injuring the derrick by flying pieces of rock, this method of boulder breaking cannot be recommended under such circumstances. One mode of breaking up boulders when derricks are used, is to raise up a heavy iron weight, and by tripping it, drop it on the stone to be broken. The weight is generally a ton. The writer has seen this method used to break metal around blast furnaces and stone in quarries, and as it is a money-saving device, its use could be much extended.

CABLEWAYS.

(3) Cableways have been used in erecting masonry and other structures, and for transporting materials, but their use has been limited as a labor-saving device to handle rock excavation. In many cases where a large amount of rock excavation is to be made, cableways could be used advantageously both to load the boulders and also to transport them. In large cuts on railroads and in reservoir and canal work they can be operated more economically than almost any other machine. The size of the boulders and methods of handling them would be similar to the work done by derricks. The objection is the great cost of the plant and installation thus limiting the use to only the heaviest work.

SLEDS OR LIZARDS.

(4) In a rock cut on a railroad a capable foreman can make a stone sled or lizard play a prominent part in handling boulders cheaply. It is hardly necessary to describe the sled, as any laborer can make one, and each foreman will have one built to suit his own ideas. By having a pair of stretchers and a set of lead harness in the cut, the mules used in the carts can be quickly transferred to the sled whenever needed. By this means many boulders measuring from one-quarter to one cubic yard, or more, can be handled from the cut to the dump without being broken up. Directly after a blast has been made, the cut always has a number of large boulders in it, and it is at such times that a sled will be found of most use. At such times sleds may be used as long as an hour and more yardage be moved at less cost, both for labor and explosive, than by loading the same material into either cars or carts. In order to turn over and load some of the largest boulders several chains will be needed, and to obtain the best results three sleds should be used. An assistant must be given to the driver to hook and unhook the stretchers on sleds, and the gang of men should be divided into a loading and an unloading crew. With these provisions made, while one sled is being loaded, another one can be unloaded, and the third can be pulled to the dump by the mules. This arrangement will get the greatest possible amount of work out of both the men and the team. Three or four three-inch rollers will be found advantageous on the dump, for the team can be made to pull the sled on to the rollers and the dumping crew, with the help of bars and levers, can roll the sled over the edge of the embankment, thus making it dump itself.

When sleds are used, it will seldom be necessary to "mud cap" boulders as time can be gained in this way to do the needed amount of drilling for block holes. A sled can also be used to advantage in hauling and handling stones for masonry structures, should the ground not be too rough. In this way boulders that are not large enough to justify the erection of even a small der-

rick can be quarried and hauled to the site of the structure.

DUMP CARTS AND CARS.

(5) One great item of expense in handling boulders with carts or cars is the height to which the rock must be lifted in order to load it. This is not only expensive, but it becomes necessary to break up the boulder so as men can conveniently lift the pieces. Another expense item is the breaking of the cart bottom by the boulder being thrown into it. To obviate this it is well to have the cart built with sheet steel as a protection. One advantage a car has over a cart, is that it can be built so that the bottom is several inches lower than that of a cart, which will mean more work done by the men in a day's time.

With a rotary dump car (1 to 1½ cubic yard capacity) the body and spider can easily be lifted off and the trucks used as a small flat car, for boulders that could not be lifted up to the bed. At times the bottom of a solid rock cut may not be shot down to grade, and large boulders can be loaded either on to the car trucks or into the car from the high bottom. It would not be advisable to leave such a bottom in the cut to use for this purpose, but upon occasions when these conditions occur the suggestion is made to take this advantage of the loading platform that is offered. As will be shown later, these solid rock bottoms are entirely too expensive to excavate to consider leaving them in the cuts purposely. In a tunnel such advantage in loading boulders can frequently be had in working the heading and bench, especially where the bench is taken out in two lifts. A well made pair of skids can be utilized in loading boulders in a tunnel.

It is seldom that enough men can get around a boulder to lift it, when it contains more than 3 or 4 cu. ft., unless some kind of a "lifter" is used. Such a "lifter" can be made of two round poles 3 ins. in diameter and 8 ft. long, with boards 2½ ft. long nailed to them, as one would nail them to make a rough stretcher. The negroes in the South call this lifter a "devil." The "devil" is laid on the ground and the boulder rolled on it, when by means of the handles it is lifted up and the stone dumped into the car or cart. Boulders containing as much as half a cubic yard can be loaded in this manner. A word of caution may not be out of place here, for without close attention the men will want to use the "devil" in handling small boulders, that could be loaded quicker with their hands, thus wasting time.

WAGONS.

(6) Wagons can only be used in hauling boulders when derricks are at hand to load them. Small stone can be loaded in to them by hand, but even this is very fatiguing work. If a few large boulders are to be hauled by wagon and a derrick is not to be had, they can be loaded on to the wagon by hand, by taking off the wheels on one side and skiding the stone on to the wagon. Then by means of two levers the wagon gear can be raised up and the two wheels replaced.

In concluding, we might say that no matter what method is being used to handle boulders, it is incumbent upon the foreman to watch his men carefully, and use his discretionary powers at all times, so as to handle boulders at the least cost. The size to which the boulder is to be broken must be governed by the method to be used in handling it while loading. Upon some occasions it will be found that the men are breaking boulders into too small pieces. A foreman supervising men on rock excavation has his time well employed, and he should be quick at judging the best methods of doing this work.

BREAKING UP BOULDERS.

We now come to consider the different methods of breaking up boulders and the relative merits and costs of each. The following six methods can be used. (1) Boulders can be broken with plug and feathers, (2) by heating and pouring water on them, (3) by sledging, (4) by mud capping, (5) by blocking, and (6) by placing a charge of explosives under the boulders. Each of these modes has its uses and misuses, and it is hoped to point out a few of these, and give some cost data.

PLUG AND FEATHERS.

(1) Drilling the rock with a hand-drill and then splitting with plugs and feathers is of great use, when the stone is to be used for building purposes as for culverts and bridges. The cost of this work varies according to the hardness of the rock, the size to which the stone is to be broken and the price paid for such work. Good hand-drillers are paid from $1.50 to $3.50 per day, according to the locality. In the South negro hand-drillers are paid $1.50, while in some sections union stone cutters do this work for which union wages are paid. In soft sandstone a good hand-driller can drill a hole 3 ins. deep in 3 mins., while in the harder sandstone and gneiss from 5 to 7 mins. will be necessary, and in the hardest granite 10 mins. may be consumed. These conditions make it difficult to give any idea of cost of breaking boulders by this method. When an air compressor is at hand this work can be cheapened by the use of pneumatic drills.

This method can also be used to advantage in soft tunnels, where it is necessary to break up boulders, and the material is such that even a slight explosion will cause cave-ins and otherwise injure the work. In dressing up the slopes of cuts and the sides and roofs of tunnels, it is sometimes necessary to take off small projections, and the use of explosives may be prohibited, then plugs and feathers will be useful and will at times save money. The following are the costs of some examples of this class of work, hand-drillers being paid $1.50 for 10 hours' work:

1¼ cubic yards were taken off the slope of a sandstone cut at a cost of $1.50.

3 cubic yards were taken off the slope of a sandstone cut at a cost of $2.25.

16 cubic feet were taken off the side of a sandstone tunnel for 75 cents.

½ cubic yard was taken off the roof of a sandstone tunnel at a cost of $2.50.

In ordinary work this method is entirely too costly and too slow.

THE HEATING OF BOULDERS.

(2) The heating of boulders to facilitate their breaking has only a limited use from an economical and practical standpoint. No one would wish to use it in a railroad cut and similar places, but there are times when it becomes both a time and money saver. The writer learned the trick when a boy from a farmer, who was clearing up a piece of woodland. Some years ago he put it to excellent use, when he was clearing a piece of timber land to grade streets through it for a land development company. The land was covered with surface boulders of trap or "negro head" rock. It was necessary to burn the brush and top wood. Accordingly the wood was piled in heaps around the boulders, and when the rocks were still hot, water was thrown over them, causing them to crack and break, necessitating but little work with a sledge and none with explosives. In this instance as the wood had to be burned, the only cost was the putting on of water —certainly a great saving in money. This method can be recommended for similar uses, and especially for surface boulders of 4 cu. yds. or less. Larger boulders cannot be heated enough. Anyone trying this method for the first time should be warned against small pieces of rock popping off when the water is poured on. This was found to happen now and then with trap rock.

The boulder must be heated thoroughly before pouring the water upon it, to insure breaking, for when only partly heated the surface only spalls off, as was the case in the Baltimore fire of Feb. 7 and 8, 1904, where a great part of the stone work in the fire-resisting buildings were injured by the fierce heat of the flames. Engineering News published a number of photographs of stone injured in this manner, and few, if any, of those illustrated had water dashed upon them. If a stream of water had been played upon these buildings, many of the stones would have been broken into fragments.

After the Baltimore conflagration the following test was made by some city officials, architects and builders to demonstrate the action of heat and water on rock. A large pile of granite, limestone, marble, sandstone and brick was made, and with wood, oil and other combustibles a hot fire was maintained for one hour to a temperature of 2,000°. Water was then thrown on the fire and everything spalled or crumbled to pieces except the bricks. This test clearly demonstrates the action of heat and water upon rock.

SLEDGING.

Under a competent and watchful foreman many large size boulders can be broken up with a stone sledge and gad, saving the use of explosives. A common laborer, as a rule, knows nothing of the rift of a stone and cares but little to learn. He usually begins hammering upon the face that the stone presents to the position that he happens to occupy, and unless the foreman interferes, he will waste time. Upon one occasion the writer watched a man use up ten minutes in this manner, and after the foreman and man were shown where to direct the blows, the rock was broken up so it could be conveniently handled, in less than two minutes. Frequently the use of the sledge prevents other men from working, and at all times men will stop working to watch the operation (there seems to be something fascinating about it) unless the foreman is ever watchful. For these reasons sledging of boulders should be planned out carefully and it should be the constant endeavor to have it done when the use of the hammer will not interfere with other men.

By looking closely for seams and cracks and taking advantage of these, and at other times using the pean end of the hammer with the rift of the rock, many boulders containing one cubic yard or less can be quickly broken. At times to turn the stone and to keep an air space beneath the rock will mean a great advantage in breaking the boulder. Unless the foreman is alert, the men will in most cases break up the stone too small, and will also use the pean end of the hammer, when the stone should be hit with the full face.

A gad will be found most useful in connection with a sledge, as stones can at times be split cheaply with the help of gads, when it would take considerable time to make an impression upon them with only a hammer. It is necessary to have several different size gads and some water will be useful to wet the spot upon the stone, where the gad is to be started. If good judgment is exercised in directing men in the use of the sledge and gad, money can be saved in breaking up boulders with this method over all others. The following are some records of costs of breaking up boulders by sledging: These figures do not include moving the pieces after the boulder is broken, but all the pieces could be easily handled. Wages paid were $1.50 for a working day of 10 hours.

1. Hard blue sandstone, 7½ cu. ft., 1 man 3 minutes, makes a cost of ¾ cents or 2.7 cents per cu. yd.

2. Blue sandstone, 12½ cu. ft., 1 man 5 minutes, 2 men 2 minutes, makes a cost of 2¼ cents or 4.86 cents per cu. yd.

3. Blue sandstone, 16 cu. ft., 1 man 3 minutes makes a cost of ¾ cents or 1.25 cents per cu. yd.

4. Red sandstone (not so hard), 1 cu. yd., 3 men 10 minutes, makes a cost of 7½ cents per cu. yd.

5. Blue sandstone, 12 cu. ft., 2 men 8 minutes, makes a cost of 4 cents or 9 cents per cu. yd.

6. Red sandstone, 23 cu. ft., 3 men 5 minutes, makes a cost of 3¾ cents or 4.1 cents per cu. yd.

7. Red sandstone, 18 cu. ft., 1 man 4 minutes, makes a cost of 1 cent or 1½ cents per cu. yd.

MUD CAPPING.

(4) "Mud capping" a boulder consists in placing a charge of dynamite, with a cap and piece of fuse inserted into the charge, upon the top of a boulder, and after covering the entire charge well with mud, exploding it. By the uniform force exerted by dynamite in all directions, the boulder is generally broken up so that the pieces can be loaded and carried away. This work can, as a rule, be done so quickly that the method has come into universal favor among foremen, but the great objection to it is the almost prohibitory cost. On account of this great loss "mud capping" should be condemned, as upon most occasions cheaper methods can be used. The only reason that should ever commend it to the thoughtful contractor, is the saving of time in preparing the shot. For this reason in thorough cuts "mud capping" may occasionally be resorted

to, but in side hill cuts and borrow pits, where the work of sledging and drilling will not interfere with the labor of the "muckers," this method should under no circumstances be used. In solid rock excavation, especially in side hill cuts, after the cut is once shot, the amount of explosives necessary to break up the material should be very small, as methods (3), (5) and (6) can be used almost exclusively, but any contractor who keeps an accurate account of explosives used at different places, will find that frequently, owing to the fact that foremen will "mud cap" almost every boulder, the cost of breaking up boulders will ofttimes exceed the original cost of loosening the material.

To illustrate this point the following figures are given: In a large tunnel approach a shot was made with 36 kegs of powder, the entire cost of explosives used for this blast being $50.91. From this shot 1,054 cu. yds. of solid rock and 512 cu. yds. of loose rock were excavated, and the cost of explosives used to break up the boulders so they could be handled was $90.54, there being over 750 lbs. of 40% dynamite consumed. The foreman in charge of this cut was considered a capable man, and each month showed a profit on his work. He nearly always "mud capped" his boulders, and as shown above, he certainly used too much dynamite. He could have made a large profit by using better judgment in breaking boulders. In this example no blocking was necessary to trim up the sides or bottom of the cut, as the work was being done in two lifts and this shot was made on the upper lift.

1. Upon another occasion, after a heavy blast was made in a thorough cut, a large sandstone boulder measuring 17 cu. yds. was thrown upon some loose material across the cut, preventing the crew of ten men from working, until it was broken up. To block it, two holes would have been necessary, and on account of the loose material under the rock it was not advisable to put the charge there. Accordingly, at a cost in labor of 30 cents, and 21 lbs. of dynamite at 13 cents per lb. and two electrical fuses costing 9 cents, making a total cost for explosives of $2.82, the stone was broken up successfully and the work went on. This was accomplished at a cost of 18.6 cents per cubic yard, and may be considered as one of the few cases where this method can be recommended.

The following are some additional records of costs of "mud capping." Labor was paid $1.50 per day of 10 hours, 40% dynamite cost 10 cents per pound, caps 60 cents per hundred and fuse 42 cents per hundred feet.

2. Red sandstone, 1.6 cu. yds., labor 8 cents, dynamite 20 cents, cap and fuse 2 cents; total cost 30 cents or nearly 18 cents per cu. yd.

3. Red sandstone, 1 cu. yd., labor 8 cents, dynamite 15 cents, cap and fuse 2 cents; total cost 25 cents.

4. Two red sandstone boulders same size, ¾ cu. yd. and same cost as follows: Labor 8 cents, dynamite 10 cents, cap and fuse 2 cents; total cost 20 cents, or 26⅔ cents per cu. yd.

5. Hard blue sandstone, 1 cu. yd., round boulder, labor 8 cents, dynamite 15 cents, cap and fuse 2 cents; total cost 25 cents. This blast did not even crack the boulder and it was shot a second time, labor being 11 cents, dynamite 10 cents and cap and fuse 2 cents, making a total cost per cu. yd. for the two blasts of 48 cents. The second shot cracked the boulder, and it was still necessary to use a sledge and gad on it, at a cost of 3 cents. Total cost 51 cents.

6. Blue sandstone, 1.2 cu. yds., labor 8 cents, dynamite 20 cents, cap and fuse 2 cents; total cost 30 cents, or 25 cents per cu. yd. This broke the boulder, but a part of it had to be sledged at a cost of 5 cents.

7. Blue sandstone, 1.4 cu. yds., labor 8 cents, dynamite 25 cents, cap and fuse 2 cents.; total cost 35 cents, or a cost of 25 cents per cu. yd. Part of this boulder had to be sledged, a cost of 4 cents.

8. Blue sandstone 7-10 cu. yd., labor 8 cents, dynamite 10 cents, cap and fuse 2 cents. This blast only chipped off a few pieces, and it was necessary to shoot again when the boulder was broken up entirely. Labor 11 cents, dynamite 15 cents, caps and fuse 2 cents; total cost 48 cents, or 68⅔ cents per cu. yd.

9. Blue sandstone, ½ cu. yd., labor 8 cents, dynamite 7½ cents, cap and fuse 2 cents; total cost 17½ cents, or 52½ cents per cu. yd.

10. Blue sandstone 1.3 cu. yds., labor 11 cents, dynamite 20 cents, cap and fuse 2 cents; total cost 33 cents, or 25.4 cents per cu. yd. This boulder then had to be sledged at a cost of 6 cents.

11. Blue sandstone .45 cu. yd., labor 11 cents, dynamite 15 cents, cap and fuse 2 cents; total cost 28 cents, or 62.2 cents per cu. yd. As this did not break the boulder up entirely a sledge had to be used, but only a blow or two was necessary.

12. Blue sandstone ½ cu. yd., labor 11 cents, dynamite 15 cents, cap and fuse 2 cents; total cost 28 cents, or 56 cents per cu. yd. Then the rock had to be given a few blows with a sledge.

13. Blue sandstone ½ cu. yd., labor 11 cents, dynamite 10 cents, cap and fuse 2 cents; total cost 23 cents, or 46 cents per cu. yd.

14. Blue sandstone ½ cu. yd., labor 10 cents, dynamite 7½ cents, cap and fuse 2 cents; total 19½ cents, or 39 cents per cu. yd.

15. Blue sandstone 1.7 cu. yds., labor 10 cents, dynamite 17½ cents, cap and fuse 2 cents; total cost 29.5 cents, or 17.3 cents per cu. yd. Part of the boulder had to be sledged at a cost of 2 cents.

16. Blue sandstone 1 cu. yd., labor 10 cents, dynamite 7½ cents, cap and fuse 2 cents; total cost 19½ cents.

17. Blue sandstone 1 cu. yd., labor 10 cents, dynamite 12½ cents, cap and fuse 2 cents; total cost 24½ cents.

BLOCKING.

(5) The "blocking" of boulders is a much cheaper way of breaking them up than "mud capping." It should always be used in preference to that method except when too much time will be consumed by a crew of men waiting for the drilling to be done, as shown in example of cost No. 1, as given under "mud capping." Under such circumstances the time consumed would be a greater cost to the contractor than the extra amount of dynamite. Then, too, on large thin boulders to drill one hole would result only in breaking the stone into such pieces as would again have to be broken; and the many holes might equal the cost of the extra dynamite. Under such circumstances if method (6) cannot be used, "mud capping" will have to be resorted to, to do the work economically.

A hole properly charged and covered with mud will effect a saving of from 60 to 70 per cent. of dynamite, over "mud capping." The bottom of cuts should always be blocked, as this sort of work can always be planned ahead, and it is the only way a shallow rock bottom can be taken up accurately and at a minimum cost. Of course machine drills on this class of work will save money over hammers and drills. Surface boulders, where it is not possible to use method (6) should always be "blocked." Occasionally on very large surface boulders black powder can be used, but as a rule dynamite will be given the preference, unless it is desired to use the stone for building purposes, when engineers will forbid the use of dynamite. This has even been done in some cases where the stone is to be used for concrete.

In the following examples of costs the prices were the same as those named under "mud capping."

1. Red sandstone boulder, 13 cu. yds., broken up entirely.

Drilling 3 ft. hole, at 35 cts. per foot	$1.05
Dynamite	.20
Cap and fuse	.02
Labor	.18
	$1.45

Cost, per cubic yard, 11.1 cents.

2. Blue sandstone, 3 cu. yds., broken up entirely.

Drilling, 1-ft. hole	$ .40
Dynamite	.10
Cap and fuse	.02
Labor	.08
	$ .60

Cost, per cubic yard, 20 cents.

3. Red sandstone, 4½ cu. yds., broken up entirely.

Drilling 1½-ft. hole	$ .52
Dynamite	.12
Cap and fuse	.02
Labor	.10
	$ .76

Cost, per cubic yard, 16.9 cents.

4. Blue sandstone, 2½ cu. yds., entirely broken up.

Drilling 1-ft. hole	$ .30
Dynamite	.08
Cap and fuse	.02
Labor	.05
	$ .45

Cost, per cubic yard, 18 cents.

5. Blue sandstone, 2 cu. yds., entirely broken up.

Drilling 7-in. hole	$ .20
Dynamite	.10
Cap and fuse	.02
Labor	.04
	$ .36

Cost, per cubic yard, 18 cents.

In all these cases boulders were broken up so that they could be loaded by hand. The item of labor is the time consumed by the crew of men in putting mud on the charge and leaving and returning to the cut. In case No. 1, this item is large as that boulder was broken alone, but in the other cases a number were broken at one time. In case No. 3, but one other boulder was broken with it, so again this item is comparatively high.

PLACING CHARGE UNDER BOULDER.

(6) The method of placing the charge of dynamite under the boulder in order to break it has not been used extensively, and for this reason it is difficult to obtain costs of this method. That it can and should be used on account of its cheapness over other methods, should commend it to contractors. The charge can easily be placed under the rock by either raising the boulder up with bars or levers, or churning a hole under it with a drill. In some cases the boulder can be turned over and the charge placed, as this is being done. At least 50 to 60 per cent. of the charge necessary to "mud cap" a boulder can be saved by this method, and the work can be done as quickly. The rock, as a rule, will not only be broken up, but most of it will be thrown out of the cut. For this reason, where there can be no waste of material, engineers may prohibit this method. Of course where the material that the boulder may be lying on is soft, this method cannot always be used successfully. Its greatest use will be found on hard rock bottoms, also in breaking up and moving surface boulders.

The following examples of costs are given for boulders broken in this way:

1. A surface boulder containing 50 cu. yds. was moved off the right of way, at the following cost:

4 kegs of powder at $1.64	$6.56
Cap and fuse	.40
2½ lbs. dynamite at 16 cts. per lb.	.04
Labor	5.50
	$12.50

Cost per cubic yard, 15 cents.

The labor consisted of one foreman one day at $3.00, 2 men a day at $1.00 per day, and one boy a day at 50 cents. The entire boulder was moved a distance of at least 40 feet. The labor item was large, as it was necessary to carry a large amount of sand to be used in tamping the load well under the boulder.

2. A red sandstone boulder, 9 cu. yds., was completely blown away at the following cost: Labor 10 cents, dynamite 5½ cents, cap and fuse 2 cents; total cost 17½ cents; cost per cu. yd. 19.4 cents. Labor in this case was $1.35 per day and dynamite cost 11 cents per pound.

3. A large boulder sticking into the base of the slope of a cut had 1½ cu. yds. shot of it by putting the charge under the projecting end. Labor 13 cents, dynamite 16½ cents, cap and fuse 2 cents; total cost 31½ cents; cost per cubic yard 21 cents. About half a cubic yard was thrown out of the cut and the rest was broken up, so it could be handled. Labor and dynamite cost the same as in case No. 2.

The next three cases were all blue sandstone, and the boulders were entirely blown away except in case No. 6, where about 1½ cu. ft. remained in the cut. Labor was paid $1.50 and dynamite cost 10 cents per pound.

4. Boulder 1½ cu. yds., labor 9 cents, dynamite 8 cents, cap and fuse 2 cents; total cost 19 cents, cost per cu. yd. 15.2 cents.

5. Boulder 1 cu. yd. Labor 9 cents, dynamite 5 cents, cap and fuse 2 cents, cost per cu. yd. 16 cents.

6. Boulder 2¼ cu. yd. Labor 9 cents, dynamite 8 cents, cap and fuse 2 cents, total cost 19 cents, cost per cu. yd. 8.4 cents.

The following table shows the costs of methods (3) (4), (5) and (6), and allows a comparison:

(3) Sledging		(4) Mud Capping		(5) Blocking		(6) Charge Beneath	
Contents. cu. ft.	Cost. cu. yd.	Contents. cu. yds.	Cost. cu. yd.	Contents. cu. yds.	Cost. cu. yd.	Contents. cu. yds.	Cost. cu. yd.
7½	$0.027	17.	$0.186	13	$0.111*	50.	$0.15* †
12½	.049	1.6	.180	3	.200	.9	.194*
27	.075	1.0	.250	4½	.169	1.5	.21*
23	.041	¾	.266	2½	.180	1.25	.152
12	.090	1.	.510	2	.180	1.	.16
18	.015	1.2	.290			2.25	.084
		1.4	.280				
		.7	.685				
		½	.525				
		1.3	.303				
		.45	.622				
		½	.560				
		½	.460				
		½	.390				
		1.7	.183				
		1.0	.195				
		1.0	.245				

*Only one boulder broken at a time. † Black powder used in this case. Rest 40% dynamite.

All the cases cited are actual examples of work done, and it can be stated that both time and explosives were wasted in some cases, for these records were made without either foremen or men being aware that the minute hand of a watch was on them. For this reason deductions made from the table are of enhanced value.

It will be noted that the average cost per cubic yard for breaking boulders by (3) sledging was 5 cents, by (4) "mud capping" 36 cents, by (5) blocking 17 cents, by (6) placing charge underneath boulder 15 cents. Three of the six cases of method (6) were broken up by themselves, so all the time consumed by the crew in leaving the cut and returning to it was charged to them, thus making the cost higher in comparison to the examples given under the other methods, where in some cases 7 or 8 boulders were broken at one time. In spite of this the cost for (6) is low and the result of these records easily teach their own lesson.

TRIMMING ROCK SLOPES.

In connection with the breaking up and handling of boulders it may be of interest to consider some cost data as to taking down some rock slopes and taking up some rock bottoms. The work considered had been started by a contractor, who had allowed his foremen to run up on the bottom of the cuts, and this caused them to leave the cuts narrow. After this contractor gave up the work, it was necessary to widen the cuts and make the bottoms conform to the profile grade. This work, for the most part, consisted of throwing down with dynamite large masses of rock, and after breaking up the boulders, hauling them to the embankments. The work was done in the winter time, and labor was paid $1.50 for a ten-hour day. Dynamite cost 10 cents a pound, black powder $1.20 per keg, caps 60 cents per hundred and fuse 42 cents per hundred feet. Foremen were paid from $3.00 to $3.50 per day. One man drove 2 carts and mules, and a cart and mule was rated at $1.00 per day. Boys were paid $1.00 per day.

Case No. 1. This was taking down a solid breast of rock about 10 feet deep on the side of a cut. The material was hard blue sandstone, and water dripped at all times from the rock, making the bottom of the cut wet. The cost was:

Foreman, $3.50 per day	$07.55
Labor	240.75
Driver	21.00
Mules and carts	37.60
Explosives	61.35
Miscellaneous	.10
	$428.35

In all 626 cu. yds. of solid rock were excavated, making an average cost of 68.4 cents per cu. yd. The average haul was 225 feet. The itemized cost for each yard would be:

Foreman	$0.108
Labor	.384
Hauling	.093
Explosives	.098
Miscellaneous	.001
	$0.684

Case No. 2. In this cut both slopes had to be worked back to the cross section stakes and the bottom had to be blocked out. The material was red sandstone. No driver was used for the mules, as the haul was so short that the dumpman did the driving. The cost was:

Foreman, $3.00 per day	$58.80
Labor	236.50
Mules and carts	39.20
Explosives	52.60
Miscellaneous	.10
	$387.20

484 cu. yds. of solid rock were excavated from this cut, at an average cost per cu. yd. of 80 cents. The haul was 150 feet. The itemized cost per cu. yd. was:

Foreman	$0.122
Labor	.488
Hauling	.081
Explosives	.108
Miscellaneous	.001
	$0.800

Case No. 3. The blue sandstone was entirely in the bottom of this cut, giving about a five-foot breast at the highest point. Nothing had to be done to the slopes. The cut was wet. One and one-half yard rotary dump cars were used on a wooden rail. One mule was used for the two cars, and these were rated at $1.50 per day. The cost was:

Foreman, $3.00 per day	$48.30
Labor	138.50
Driver	15.00
Mule and cars	23.10
Explosives	39.65
Miscellaneous	10.18
	$274.73

The total yardage moved was 415 cu. yds. of solid rock, at a cost of 66 cents per cu. yd. The haul was 325 feet. The itemized cost per cu. yd. was:

Foreman	$0.116
Labor	.334
Hauling	.091
Explosives	.095
Miscellaneous	.024
	$0.660

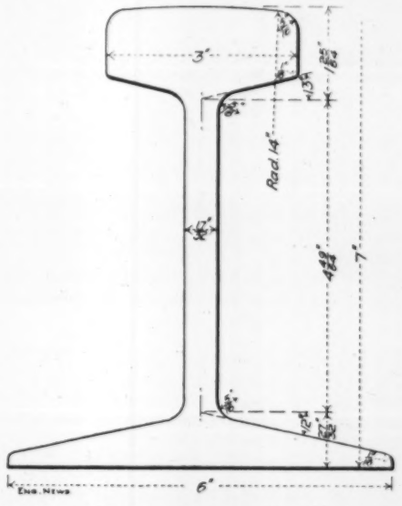
These cases show the extra expense caused by incompetent workmen, as this work could have been done with the rest of the cut much cheaper than is here shown. The work amounted to little more than handling a mass of large and small boulders, and both the cost of labor and explosives were high.

T-RAILS FOR STREET RAILWAY TRACK CONSTRUCTION AT MILWAUKEE, WIS.

A 7-in. T-rail weighing 95-lbs. per yd. has been adopted by the Milwaukee Electric Railway & Light Co., of Milwaukee, Wis., for its standard track construction in city streets. The form of section is shown in the accompanying cut, and the rails are 60-ft. long, with cast-welded joints. The company does its own welding, having purchased the right to use the Falk system, and it has no trouble from fractures at the joints. The metal is so thoroughly fused as to ensure a complete weld, so that there is no actual joint or break in the continuity of the metal, and this is so effective that no bonding is required. As a rule, the conductivity at the joint is about 100% of that of the rail, and runs up in some cases as high as 140%. Whenever a test shows that the conductivity is less than 80% of that of the rail, the joint is broken out and rewelded, but this is very rarely necessary. Bolted splice joints are used for connection with special work at intersections, etc.

The rails were rolled at the Lackawanna Steel Co.'s new mills at Buffalo, N. Y. The street railway company's specifications included the following requirements as to chemical composition: carbon, 0.55 to 0.65%; phosphorus not to exceed 0.09%. The smaller rails for interurban lines are required to have carbon 0.45 to 0.55%, and phosphorus not exceeding 0.10%. The adoption of these high and heavy T-rails was due to Mr. John I. Beggs, President and General Manager of the Milwaukee Electric Railway & Light Co., who was a member of the American Street Railway Association's committee on standards which in 1902 presented a report recommending the use of the T-rail with a head 3 ins. wide. This report was adopted by the Association.

The rails are laid on wooden ties 2 ft. apart, with concrete 6 ins. deep under the ties and filled in level with the tops of the ties. It is considered that this gives a certain elasticity or cushioning to the support of the rail, while the laying of the rails directly upon a continuous bed of concrete would make too rigid a track, although this practice is used with satisfactory results in other cities (Engineering News, March 6, 1902). On each side of each rail is a line of granite blocks, laid alternately as headers and stretchers. These are grouted with tar or gas-house refuse. On the inside of the rails, the corners of the blocks are beveled to form the groove for the wheel flanges, and the blocks extend under the rail head as far as the web, so that they cannot rise above the rail and make a rough place in the pavement.



7-in. 95-lb. T-Rail for the Milwaukee Electric Railway & Light Co., Milwaukee, Wis.
Lackawanna Steel Co., Makers.

The use of the side-bearing or step rail has been abandoned, as with the large flanges of the wheels of the interurban cars a slight wear of the rails and wheels soon allowed the wheel flanges to ride on the rail. This form of rail was also objectionable in inducing teamsters to keep their wagons on the track, thus obstructing the track, especially as it is difficult to turn out from such a track. With the new rail there is much less inducement for teams to follow the track.

The company's interurban lines are laid with 75-lb. rails of the Am. Soc. C. E. section, and it is proposed to adopt an 80-lb. rail as standard. These rails (whose chemical composition has already been noted) have bolted splice joints, bonded in the usual way.

REINFORCED CONCRETE PILES to the number of 580 were employed in the foundations of the new railway station at Hamburg, Germany. The soil on which the station is built consists of strata of sand, marl and clay of varying thicknesses, and carrying a great deal of water. The piles used were 36 x 36 cm. square and 7 m. long, and were reinforced with four 25 mm. round bars tied together at intervals by wire and having a metal shoe. The piles were removed from the forms in three days and allowed to harden for two weeks before driving. They were driven by pile driver, with a hammer weighing four metric tons, having a drop of 1.2 m. The safe load was calculated by the formula of Brix:

$$p = \frac{h\,Q^2\,3}{2\,e\,(Q+3)^2},$$

in which p = safe load in kilograms; h = height of fall in centimeters; Q = weight of hammer in kilograms; e = last penetration in centimeters, and 2 is a coefficient of safety.

A NEW FORM OF REINFORCED CONCRETE BLOCK SEWER CONSTRUCTION.

By Walter C. Parmley,* M. Am. Soc. C. E.

The accompanying illustrations explain a new form of reinforced concrete block sewer construction designed by the writer for sewers and other conduits of small size. Fig. 1 shows a loaded section of sewer of this construction. The section is 2 ft. long, 42 ins. in diameter and has a 4-in. thickness of shell. It is supported on a cradle of concrete extending about 45° each way from the bottom. The external load is a pile of building stones and crushed stone, 3 ft. thick, thus overhanging the sewer 6 ins. front and back, and weighing 9,125 lbs. No deflection, either vertical or horizontal, was produced by this load, and no hair cracks were developed.

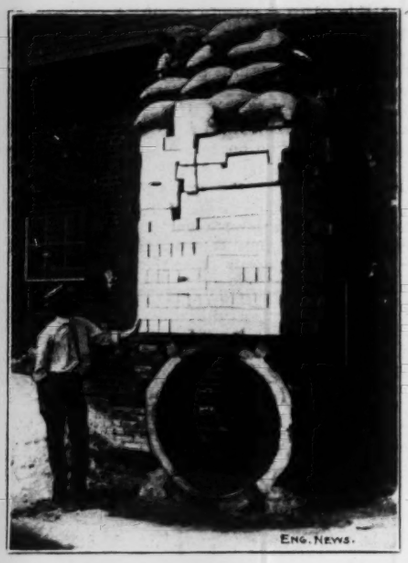


Fig. 1. Load Test of Section of Reinforced Concrete Block Sewer.

A sewer of this type is built of manufactured concrete blocks, so constructed as to fit together in the trench and embed a reinforcing steel skeleton. Each ring may consist of any number of blocks, a convenient number being four, each block forming the quadrant of the circle, as shown in Fig. 2. By this construction the joints occur where the bending moments are minimum and where the resultant of all the forces acting is nearly a tangential thrust. The two side blocks and arch block may be made identical with circular or octagonal external outline, or, the corners may be rounded off for the arch block, leaving the vertical sides as shown in Fig. 2, for better abutment support in earth trench. For egg shaped sewers, the arrangement of the blocks would be somewhat different.

The blocks may be made any convenient length, say, 1 ft. The bottom blocks are preferably made square on the ends, so that they are laid with butt joints in Portland cement mortar.

In longitudinal section, the side and arch blocks are shown by Fig. 3. The front end of each block has a projecting lip next to the intrados which closes up against the rear end of the next block, thus forming a groove around the sewer, in which the steel rods are embedded in Portland cement mortar. This is shown in Figs. 3 and 4. While the side and arch blocks are thus set so as to form continuous grooves and rings around the sewer, they break joints with the bottom blocks.

In building the sewer, the bottom blocks are first set in mortar to line and grade. Before the upper blocks for any particular sewer ring are set in position, the steel rods or bars are placed against the face of the preceding ring and held by plastering against them a portion of the mortar that is to embed the bars. After the block is set, the joint is completely filled with a soft mortar, or, simply poured full with mortar grout. It is convenient to have a hook and eye joint in the rods just above the tops of the side blocks, as short rods are more easily held in position than long ones.

The arch is bonded longitudinally by embedding in the mortar of the radial joints between the side and the arch blocks, thin strips of band iron, each piece being longer than the block, so as to project forward into the joint of the next ring, as shown by broken lines in Fig. 3.

The blocks are made preferably in iron molds, using a comparatively dry concrete of about 1:3:5 proportions and using small broken stone, or, a 1:2:3 concrete will produce a still stronger product. The blocks are removed from the molds as soon as made and before they have begun to take the initial set. Fig. 4 shows several of these blocks ready for use. The concrete used in making the blocks of which the test section, Fig. 1, was constructed was composed of 1 Vulcanite Portland cement to 2½ sand and 4½ Bedford limestone crushed to pass through a ¾-inch ring and with the fine dust removed. The blocks had an inside finish of 1 to 2 mortar. The concrete was mixed fairly dry and was well rammed in the mold. The blocks were removed from the mold immediately after the ramming was completed.

Each foot of the section shown in Fig. 1 is reinforced with an inner and outer set of 5-16-in. round soft steel rods, as shown by broken lines in Fig. 2. The inner rod passes through the bottom block and connects with the side inner rod at the lower joints, while the outer rod stops at the lower joint.

The stress in the concrete and the steel involves all the considerations of the ordinary case of reinforced concrete, complicated by the circular form of the structure. It should therefore be noted that the section tested is not butressed or supported at the sides, as all sewers are in actual practice, and that the load is really carried by the sides which are already curved some 6 in. out of a vertical line. Under these circumstances, the behavior of the section under load is really remarkable. Some of the advantages of this type of sewer are:

(1) ECONOMY.—(a) On account of the thin side walls and the method of constructing the sewer, a less quantity of excavation is required than for either a brick or a vitrified pipe sewer.

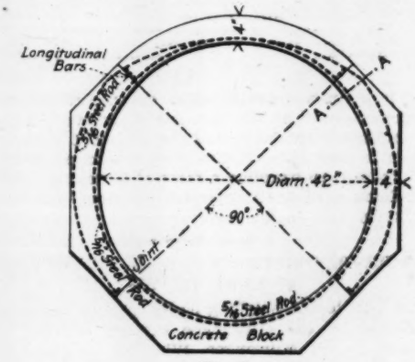


Fig. 2.
Elevation.

Fig. 3.
Section A–A.

Figs. 2 and 3. Details of a 42-in. Reinforced Concrete Block Sewer.

(b) The alinement and grade can be easily and accurately secured by laying the invert blocks in advance of the building of the remainder of the sewer, and they can always be kept built close up with the finished portion of the excavation. (c) No centering is required for this type of sewer—only a light removable template to assist in accurately adjusting the blocks. The arch at all times is self sustaining. (d) Backfilling can begin as soon as the arch is completed, which ought not to be done in case of a brick sewer where from one-fourth to one-third of the entire mass of mas is soft mortar. (e) Cheapness of the mat used, as concrete is the least expensive buil material at the present time. (f) The blocks be made anywhere, even alongside the se trench. Freight and teaming charges are th fore avoided, which cannot usually be done w bricks are used. (g) Sewer can be construct the trench rapidly and easily—probably mor than any other kind of sewer.

(2) SUPERIOR CHARACTER OF WOR (a) Very great strength for a minimum quan of material used. (b) For pressure conduits unlimited durability—as against the limited of iron pipes on account of the rusting of the i

Fig. 4. View Showing Blocks for Reinforced Concrete Block Sewer.

(c) The invert blocks can be more accurately laid than bricks or large sizes of vitrified pipes. They should be as even in surface as the blocks in a sidewalk. Obstruction to the flowing water is thus reduced to a minimum. (d) Small internal friction; on account of the smoothness of the blocks, the capacity of the sewer is greater than for ordinary pipe or brick sewers of same grade and diameter. (e) Impermeability; the amount of water which can pass through the sewer is very small on account of the density of the blocks. (f) The sewer can be more successfully laid in a wet ditch than a brick sewer, because, on account of the small amount of mortar used in setting the invert, contact with water before the mortar has hardened is less harmful than it is to freshly laid brick masonry. (g) Adaptability for conduits, sustaining internal pressure, for which work vitrified pipe and brick masonry are entirely unsuited.

114 Liberty St., New York City.

ANALYSIS AND DESIGN OF A REINFORCED CONCRETE RETAINING WALL.

By F. F. Sinks.*

Considerable information has been published from time to time concerning reinforced concrete structures for all railway purposes with the exception of retaining walls. In track elevation, concrete retaining walls are being used quite extensively; these are usually very massive, and it would appear that reinforced concrete could be used quite economically in such walls, if the volume of concrete could be reduced to some extent, at the same time keeping the cost of supervision, of forms, and of mixing and placing the concrete the same as for the plain wall. The design presented here was to meet these requirements and at the same time have as much, if not more, stability than the average design of retaining wall.

The following assumptions, methods of design and ideas of construction, were used in this design: The type of wall selected was a wall having the same general outline as an ordinary retaining wall, to which any reliable theory could be applied. The plane A B (Fig. 1) was assumed to be the back of the wall and the prism of earth A-B-C-D-A a part of the wall. The weight of this prism is less than one-fourth the total weight of wall. The resultant pressure due to weight of wall and earth pressure (without surcharge) must cut the center, or very near the center, of the

*1750 Monadnock Block, Chicago, Ill.

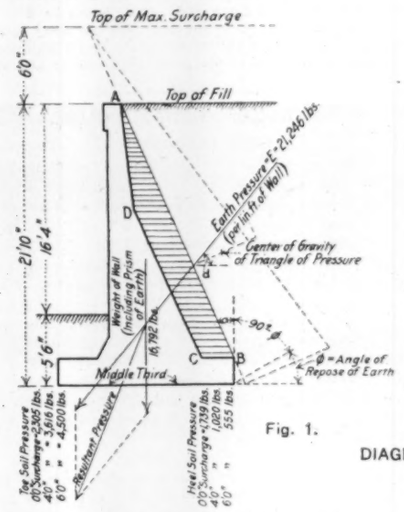
ase. The resultant due to the above pressures nd including the surcharge must cut the base nside the middle third. At the same time the llowable soil pressure must not be exceeded at he toe. The forms must be as simple and readly constructed as for plain walls. The reinorcing bars must not have any difficult kinks or ends, so as to avoid the necessity of skilled labor n the field. The volume of concrete shall not be educed to such an extent that the cost per yard f machine mixing, handling and placing of conrete will exceed that for a plain wall.

combined with the weight of the masonry above the plane "BB." The resultant pressure cuts the plane "BB" just inside of the masonry at the toe and produces a negative pressure at the heel. Care must be taken not to exceed the allowable pressure on the masonry at the toe in the plane "BB." Reinforcing bars are to be provided to take the stress caused by negative pressure at the heel. Fig. 2 also shows the resultant pressure on the upper portion of the wall. This portion is treated as a simple cantilever beam.

Fig. 3 shows cross section of completed wall giving sizes and spacing of reinforcing bars. Fig. 4 shows cross section of a plain concrete wall, having the same stability as the reinforced concrete wall. The following comparison of costs are for the total cost of wall including profit and exclusive of excavation:

Cost of plain concrete wall, per lineal foot:	
Concrete, 4.8 cu. yds. @ $4 per yd. in place	= $19.20
Forms, 115 ft. B. M. @ $31 per M. in place	= 3.56
Total	$22.76
Cost of reinforced concrete wall, per lineal foot:	
Concrete, 3.46 cu. yds. @ $4.10 per yd. in place	= $14.18
Forms, 115 ft. B. M. @ $31 per M. in place	= 3.56
Steel bars, 109 lbs. @ 3¼ cts. per lb. in place	= 3.54
Extra fill, 1.34 cu. yds. @ 20 cts. per yd.	= 0.27
Extra excavation, 0.32 cu. yds. @ 20 cts. per yd.	= .06
Total	$21.61

These estimates show a saving of $1.15 per lineal foot of wall, in favor of the reinforced concrete wall. If the cost of materials is higher, there will be a greater saving made.


Top of Max. Surcharge
Top of Fill
Earth Pressure E=21,246 lbs. (per lin. ft. of Wall)
Center of Gravity of Triangle of Pressure
Weight of Wall (including Prism of Earth) 16,792 lbs.
Middle Third
Resultant Pressure
ϕ=Angle of Repose of Earth
Toe Soil Pressure
Heel Soil Pressure
Fig. 1.

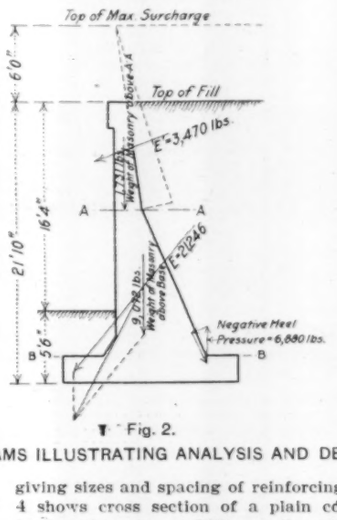


Fig. 2.

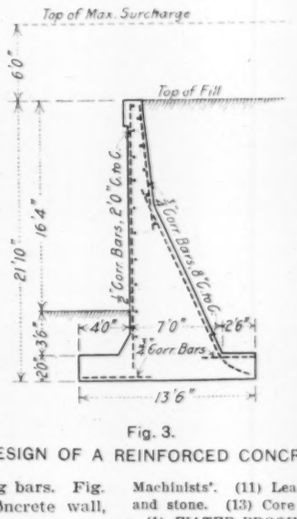


Fig. 3.

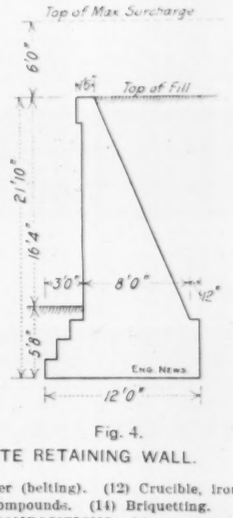


Fig. 4.

DIAGRAMS ILLUSTRATING ANALYSIS AND DESIGN OF A REINFORCED CONCRETE RETAINING WALL.

Retaining wall formulas were taken from "Retaining Walls for Earth" by Prof. M. A. Howe, and the following are the ones used for the resultant earth pressure and its pitch:

$$E = \frac{H^2 y}{2}\sqrt{\tan^2 a + \tan^4\left(45° - \frac{\phi}{2}\right)}$$

$$\text{Tan } d = \frac{\tan a}{\tan^2\left(45° - \frac{\phi}{2}\right)}$$

where H = vertical height of wall plus the surcharge.
W = weight of cubic foot of concrete = 150 lbs.
Y = weight of cubic foot of earth = 100 lbs.
ϕ = angle of repose of earth = 30°.
a = angle back of wall makes with the vertical.
E = resultant earth pressure, in pounds per lineal foot of wall.
d = angle, resultant E makes with the horizontal.

The formula used for the reinforced concrete is by Mr. A. L. Johnson. This formula can be adapted to either a high or low elastic limit steel.

The metal reinforcing used is a steel of high elastic limit, and the allowable unit stress for tension is 12,500 lbs. per sq. in., which gives a factor of safety of 4, where the elastic limit is 50,000 lbs. per sq. in. If steel of 32,000 lbs. elastic limit is used, the allowable unit stress should be 8,000 lbs. per sq. in. in order to have the same factor of safety. The allowable working stress for imbedment of the bars shown is 250 lbs. per lin. in. of imbedment and for plain material about 160 lbs. per lin. in. of imbedment. The above unit stresses are based upon tests made at six of the leading universities of this country, said tests proving without a doubt that the ultimate strength of the reinforced concrete structure is the elastic limit of the steel reinforcing. The method of precedure was as follows:

Fig. 1 shows the direction and intensity of the resultant for 6 ft. of surcharge. The soil pressure at the heel and toe are shown for 0, 4 and 6 ft. of surcharge. The toe is reinforced for the maximum soil pressure and the heel for the actual weight of the earth prism.

Fig. 2 shows the resultant earth pressure E applied directly to the back of the masonry and

NOTES ON LUTES AND CEMENTS USEFUL TO ENGINEERS.*

By Samuel S. Sadtler.†

In a recent paper read by me before the Chemical Section of the Franklin Institute I treated in a general way of the subject of lutes and gave some examples under the following heads: (1) Plaster of Paris; (2) hydraulic cement; (3) clay; (4) lime; (5) asphalt and pitch; (6) resin; (7) rubber; (8) linseed oil; (9) casein and albumen; (10) silicate of soda and chloride cements; (11) flour and starch; (12) miscellaneous. When asked to read a paper before this club, I thought it might be of interest to treat of certain kinds of lutes and cements most likely to be used by engineers, and arranged accordingly to the intended application.

I have taken up this subject, not because there was little to be found in literature, but because what is recorded is not very dependable and is, in most cases, vouched for by no one. It seems to be copied and abstracted from one source to another until no one would be willing to assume the authorship. A great many of the formulas given in encyclopedic works show that the authors were ignorant of the nature of the ingredients they used. Many formulas are impossible, having incompatibles from a chemical standpoint, a mistake that young doctors sometimes make in their prescriptions; then many are of foreign origin and the use of grain alcohol is referred to as if it were as cheap as petroleum naphtha; or potato-starch is used where we would use corn-starch for economy. The great bulk of them are very inferior in usefulness and a limited number are impracticable. It has been my endeavor to pick out some of the best.

With regard to the literature on this subject a great deal of information may be had in the formula books, such as those of Spon, Wahl and Brannt, a long article in Muspratt's "Handwörterbuch der Chemie," and similar places. The engineering hand-books are practically barren of any information on this subject.

I have had such repeated occasion to use luting and cementing materials for various purposes in the laboratory and works that I thought some condensed information on the subject might benefit others if brought together.

They may be classified as follows: (1) Water and steam-proof. (2) Oil-proof. (3) Acid-proof. (4) Proof to hydrocarbon gases. (5) Chlorine-proof. (6) Elastic. (7) General purposes. (8) Marine glue. (9) Gaskets. (10) Machinists'. (11) Leather (belting). (12) Crucible, iron, and stone. (13) Core compounds. (14) Briquetting.

(1) WATER-PROOF COMPOSITIONS.—Of use to engineers are the asphalt fluid coatings for reservoir walls, concrete foundations, brick, wood, etc. Asphalt only partly dissolves in petroleum naphtha, but heated in a steam-jacketed kettle and not thinned out too much, a mixture of the two may be obtained in which the part of the asphalt not dissolved is held in suspension. Asphalt is entirely soluble in benzol or toluol which are about the cheapest solvents for all the constituents of asphalt. Tar and pitch are sometimes used in this connection, but tar contains water, light oils, and free carbon, and does not wear as well as good refined asphalt; and pitch contains free carbon, which is sometimes objectionable when thinned out with a solvent. The asphalt alone is somewhat pervious to water, and this is improved by adding about one-fourth its weight of paraffin, and made better if in addition a little boiled linseed oil is added also. For thicker compositions, where body is required, asbestos, stone powder, cement, etc., may be added as fillers.

Lutes of linseed oil thickened with clay, asbestos, red or white lead, etc. are water-proof if made thick enough. These are much used for steam joints. Flaxseed meal made into a paste with water is often serviceable, the oil contained serving as a binder as the water evaporates.

(2) OIL-PROOF COMPOSITIONS.—The most useful lute for small leaks, etc., is the well-known "hektograph composition," as follows:

Good glue or gelatin	2 parts.
Glycerin	1 part.
Water	7 parts.

This is applied warm and stiffens quickly on cooling. Another very useful composition is a stiff paste of molasses and flour. Another preparation impervious to oil vapors is the "flaxseed poultice," mentioned in Sec. 1, which is proof to oil vapors.

One of the strongest cements, and one which is really oil-proof, water-proof, acid-proof, and proof to almost everything, is a stiff paste of glycerin and litharge. These form a chemical combination and set in a few minutes. If a little water is added, it sets more slowly, which is often an advantage. It is mixed when required for use. Plaster of Paris wetted, by itself, or mixed with asbestos, straw, hair, etc., is useful. A solution of silicate of soda made into a stiff paste with carbonate of lime, gets hard in six to eight hours.

(3) ACID-PROOF COMPOSITIONS.—The asphalt compositions already mentioned, compositions of melted sulphur with fillers of stone powder, cement, sand, etc.; also the following, which withstands hydrochloric acid vapors:

Rosin	1 part.
Sulphur	1 "
Fire clay	2 parts.

The lute composed of boiled linseed oil and fire-clay acts well with most acid vapors. The composition of glycerin and litharge referred to is useful in this connection, especially when made up according to the formula of Geo. E. Davis, viz.:

Litharge	80 pounds
Red lead	8 "
"Flock" asbestos	10 "

*A paper read before the Philadelphia Engineers' Club, June 4, 1904.

†Chemist, 10th and Chestnut Sts., Philadelphia, Pa.

fed into a mixer, a little at a time, with small quantities of boiled oil (about six quarts of oil being used). Sockets joined in 3-in. pipes carrying nitric acid were caulked with this and showed no leaks in nine months.

A particularly useful cement for withstanding acid vapors, being also tough and elastic, is:

Crude rubber, cut fine	1 part.
Linseed oil, boiled	4 parts.
Fire-clay	6 "

The rubber is dissolved in carbon disulphide to the consistency of molasses and then mixed with the oil. Other examples of acid-proof cements, taken from "A Handbook of Chemical Engineering," by Geo. E. Davis, and vouched for by the author, who has used them in chemical engineering work, are as follows:

"Black putty," made by intimately mixing equal portions of china-clay, gas-tar, and linseed oil. The china-clay must be well dried by putting over a boiler, etc. The author says that it is probable that anthracene oil might be used to advantage instead of gas-tar, for reasons which I stated in referring to asphalt lutes. It seems to me, however, that soft pitch or, better still, a semi-liquid asphalt or naphtha would be best.

Barytes cement is composed of pure, finely ground sulphate of barium, and is made into a putty with a solution of silicate of soda. This sets very hard when moderately heated, and is then proof against acids. Mr. F. E. Dodge has tried this and finds the gravity of the silicate of soda should be between 1.2 and 1.4, 24° to 42° Beaumé. If too thin, it does not hold; and when thicker than 1.4, it expands and breaks.

(4) HYDROCARBON GASES.—Compositions of plaster and cement, the former setting more quickly, are used. Also compositions of casein, such as:

Finely powdered casein	2 parts.
Fresh slaked lime	50 "
Fine sand	50 "

Water is added, when used, to form a thick mush. Various mixtures of silicate of soda are employed in which the thick silicate is absorbed in some inert material, as clay, sand or asbestos.

(5) CHLORINE.—The best and only reliable compositions are a few made with Portland cement, and the following is much used for electrolytic and chemical plants:

Powdered glass	1 part.
Portland cement	1 "
Silicate of soda	1 "

A small amount of powdered slate.

This lute is said to stand acid and alkali, as well as the influences of chlorine. Linseed oil made into a paste with fire-clay serves for a time.

(6) ELASTIC CEMENTS.—The various cements containing rubber are elastic, if it is in predominating amount; many containing boiled linseed oil and the hectograph composition already mentioned are quite elastic. The rubber-linseed oil cement, given under Sec. 3, is very tough and useful for nearly all purposes except when oil vapors are to be confined. The most useful single rubber lute is probably the so-called Hart's india-rubber cement. Equal parts of raw linseed oil and pure masticated rubber are digested together by heating and this mixture made into a stiff putty with fine "paper stock" asbestos. I have found it more convenient, however, to dissolve the rubber, first in carbon disulphide, and after mixing the oil with it, to let the solvent evaporate spontaneously.

(7) GENERAL PURPOSES.—One of the most useful is plaster of Paris, and especially when mixed with asbestos, straw, flush trimmings, hair, broken stone, etc., used according to temperature, strain, and other conditions. A putty of flour and molasses is a good composition to keep in a works ready for quick application when needed. It serves almost any purpose at moderate temperatures for a time. Casein compositions have great strength.

White of egg made into a paste with slaked lime is strong and efficient, but must be used promptly on account of its quick setting qualities.

(8) MARINE GLUE.—This can be purchased almost as cheaply as made. The rubber must first be dissolved in carbon disulphide or turpentine before mixing with the heated combination of the other two ingredients. Its uses are well known.

Crude rubber	1 part.
Shellac	2 parts.
Pitch	3 "

(9) GASKET COMPOSITIONS.—Of course, almost any cementing substance may be used with rings of asbestos, etc., for gaskets, but there are some that I have used and which I have known others to choose especially for that purpose.

With regard to asphalt, tar, pitch and petroleum residuum, I would recommend soft or hard pitch, as may be desired, because there are no light oils or water to go off at low heats, and the free carbon and compounds very high in carbon are good fillers to asbestos gaskets at high temperatures. Silicate of soda by itself is much used, but is sometimes advantageously mixed with casein, fine sand, clay, asbestos, carbonate of lime, caustic lime, magnesia, oxides of heavy metals, such as lead, zinc, and iron, and powdered barytes. A few that might be selected are—silicate of soda and asbestos; silicate of soda, asbestos and slaked lime; silicate of soda and fine sand; silicate of soda and fire-clay.

(10) MACHINISTS' CEMENTS.—These are the well-known red and white leads. The red lead is often diluted with an equal bulk of silica or other inert substance so as to make it less powdery. The best way that I have found to do this, however, is to add rubber or gutta-percha to the oil as follows:

Linseed oil	6 parts by weight.
Rubber or gutta-percha	1 part " "

The rubber or gutta-percha is dissolved in sufficient carbon disulphide to give it the consistency of molasses, mixed with the oil, and left exposed to the air for about 24 hours. The red lead is then mixed to a putty. Oxide of iron makes a less brittle cement than red lead. Probably fish oils and red lead would make good lutes of the class for joining pipes, as the fish oils are not such strong drying oils as linseed, and their use might be a case of permissible substitution rather than adulteration.

(11) LEATHER CEMENTS.—(For leather belting.) This subject is treated fully and well in the literature, and I only quote some formula for the convenience of the readers of this paper. Those I select seem to be the cheapest, and from a knowledge of the chemistry of the subject, the best. The following formula are given in the "Papier Zeitung," vol. 18, p. 2618:

(1) Equal parts of good hide glue and American isinglass, softened in water for ten hours and then boiled with pure tannin until the whole mass is sticky. The surface of the joint should be roughened and the cement applied hot. (2) One kilo of finely shredded gutta-percha digested over a water-bath with 10 kilos of benzol, until dissolved, and 12 kilos of linseed oil varnish stirred in. (3) 7½ kilos of finely shredded India rubber are completely dissolved in 10 kilos of carbon disulphide by treating whilst hot, 1 kilo of shellac and 1 kilo of turpentine are added, and the hot solution heated until the two latter ingredients are also dissolved.

Another one noticed in the "Journal of the Society of Chemical Industry" seems to be good:

	Ounces.
Gutta-percha	8
Pitch	1
Shellac	1
Sweet oil	1

These are melted together.

A formula from Spon's "Dictionary of Workshop Receipts" is about as follows: Fish glue is soaked in water 24 hours, allowed to drain for a like period, boiled well and a previously melted mixture of 2 oz. of rosin and ½ oz. of boiled oil is added to every 2 lbs. of glue solution. I have not verified any of these formula for leather cements.

(12) SO-CALLED IRON, STONE, AND CRUCIBLE CEMENTS.—These are all hard, stone-like compositions. The oxychloride cements, consisting essentially of oxychlorides of magnesium and zinc, are very hard and are much used in engineering construction.

STONE CEMENTS.—The formulæ which I give in my previous paper, are:

Zinc oxide or magnesium oxide	2 parts.
Zinc or magnesium chloride	1 part.
Water to make a paste.	

When dry, these become very hard and strong. Powdered stone is generally used as a diluent.

IRON CEMENTS.—When iron in a fine state of division, as in fresh filings or cast-iron borings that have been powdered, is mixed with an oxidizing agent, such as manganese dioxide or a substance electro-negative to iron, such as sulphur, in a good conducting solution like salt or salammoniac, galvanic action sets in very rapidly, and the iron swells, by forming iron oxide, and cements the mass together. It is best diluted with Portland cement. A formula which I give from memory is:

Iron filings	40 parts.
Manganese dioxide, or flowers of sulphur	10 "
Salammoniac	1 part
Portland cement	20 to 40 parts.
Water to form a paste.	

These cements are used extensively in foundries, etc.

CRUCIBLE CEMENTS.—Mixtures of clay and borax in which the clay predominates. Silicate of soda and powdered glass or sand are the best known compounds for cementing lids on crucibles, etc. Sometimes the "iron cements" are used for such purposes, or iron filings and a little manganese dioxide are added to the above compositions for crucible cements.

(13 and 14) CORE COMPOUNDS AND BRIQUETTING.—These may be treated together, as their actions are closely analogous. Some of the substances used for briquettes are: Dextrin, spoiled potatoes, grain and starchy materials, molasses, glucose, clay, sand, loams, bituminous coal, pitch, asphalt and tar, Oxychloride cement and Portland cement.

Most of these have also been used as core compounds, those most advantageously employed being probably flour, or meal of some kind, dextrin and molasses.

Briquetting requires more of a binder than is necessary for cores, and the evolution of gas is not so important; in fact, some briquette compositions use enough binder to supply carbon and reducing gases to effect a reduction of the oxides of the ore.

These are cements for various miscellaneous purposes, but the most important uses of interest to engineers have been briefly treated in this paper. A limited number, if carefully selected, would be found to answer all requirements, and it is often desirable to have a few prepared that can be used on short notice.

DISCUSSION.

E. M. Nichols.—Could fish oil be used in ordinary steam-fitting, in connection with red lead or linseed oil?

Mr. Sadtler.—Yes; it has recently occurred to me that an oil with milder drying properties than linseed might be better. Corn oil might be good for the purpose. Linseed oil gets brittle and powdery with red lead, as is noticeable when the pipes are taken apart.

Mr. Nichols.—My experience with cements used for steam fitting is that the more quickly they dry, the more perfectly they fill up any imperfections that exist in the thread of the pipe or of the fittings, and we do not desire as elastic material. There is also another purpose, as a lubricant, which will enable the workman to screw the pipe into the fitting much easier than would be done if it was not there. If the fittings and pipe are fairly accurate, plumbago and linseed oil will prove very satisfactory, although some engineers specify nothing but red lead and oil.

THE CHARLESTON BRIDGE FAILURE.

By H. G. Tyrrell.*

The suspension bridge at Charleston, West Virginia, which failed on Dec 15, went down under a load of ice and snow averaging about 4 ins. in thickness. In addition to this there were on the bridge twelve teams and about fifty pedestrians. Of this number two were killed outright, and most of the others more or less seriously injured. All of the horses that were on the bridge excepting one were drowned. The river was covered with a layer of ice 4 ins. in thickness, and many of the injuries were caused by the fall of 40 ft., striking on the ice below.

The bridge spanned the Elk River on Lovell St. in the city of Charleston. It is located about half a mile above the mouth of the Elk River where it empties into the Kanawha River. It is said to have been built in 1852, and at the time of the Civil War the cables were cut by the army and afterwards repaired. The bridge has a span of 478 ft. from center to center of towers, and a clear roadway of 16 ft. At the Charleston end the towers are 30 ft. c. to c., while at the other or Elk City end they are 34 ft. c. to c. They are 30 ft. in height, and 13 ft. square at the base on the roadway level, and 5 ft. square under the coping.

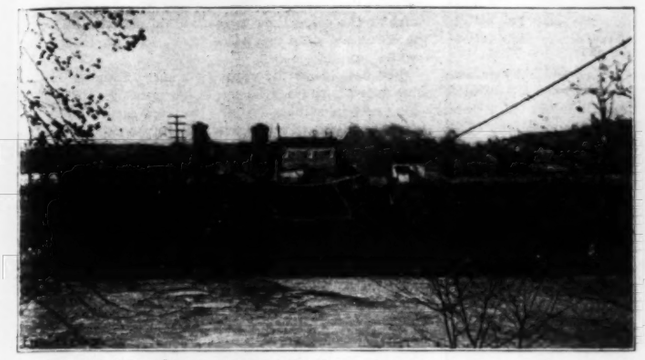
The platform or floor consisted of 2½-in. plank laid crosswise of the bridge on eight lines of 4 × 6-in. spruce nailing pieces. These nailing pieces rested directly on the cross floor-beams which were 4 × 12-in. oak spaced 4 ft. apart. Each floor beam was suspended with a cluster of 24 wires of No. 8 gage, laid parallel and wrapped at intervals of 2 ft. The suspender cables took hold of the eye of a 1-in. bolt passing through the ends of the floor beams. At the upper end of each suspender cable was a loop eye, which passed over a 1-in. yoke iron, that hooked over the cables. This detail is shown in the accompanying sketch. The bridge had no stiffening trusses.

The failure of the bridge was due to the cables pulling out from the north or up-stream anchor block on the Charleston side. There were two cables on each side of the bridge, 3 ins. in diameter, made of No. 8 gage wires laid parallel, and wound at intervals of three to four feet. One of these cables broke in the masonry, leaving all the anchor loops and irons in place, and after this cable had failed the increased load thrown on the other cable caused it to fail by shearing off a pin at the base of the first lot of loop irons, and pulling these loops clear out from the masonry. This detail is clearly shown on the accompanying drawing. The detail shows also the method employed for tightening the cables. A number of wedges were inserted between the end of the loops and the pin, and the cables shortened in this way.

The real cause of the bridge failure is probably that a radical error was made in the original design of the structure. The Charleston end is 7 ft. lower than the opposite or Elk City end, and is 5 ft. below extreme high water. A few years ago during a period of extreme high water, the river rose clear over the bridge floor, and the pressure of the water on the up-stream side caused the bridge to tilt up, at a considerable angle, which caused excessive strain on the up-stream cable, the one that failed. After the water receded, the bridge returned to its normal position, but the upper cable was strained beyond its elastic limit, and many of the wires were broken.

*2151 Fulton Ave., Walnut Hills, Cincinnati, Ohio.

Above ground the cables were found to be in a much better condition than under the stonework. They had been painted above ground and are not very badly rusted. But under the coping, where the wires were subject to frequent wettings, the wires were badly rusted. Many of them in the interior of the cable were rusted entirely through. Had these cables been properly protected from the destructive action of water at the anchorages the accident would not have happened. The concrete had become more or less disintegrated, below the coping, and this allowed the water to percolate down into the anchor blocks. Formerly



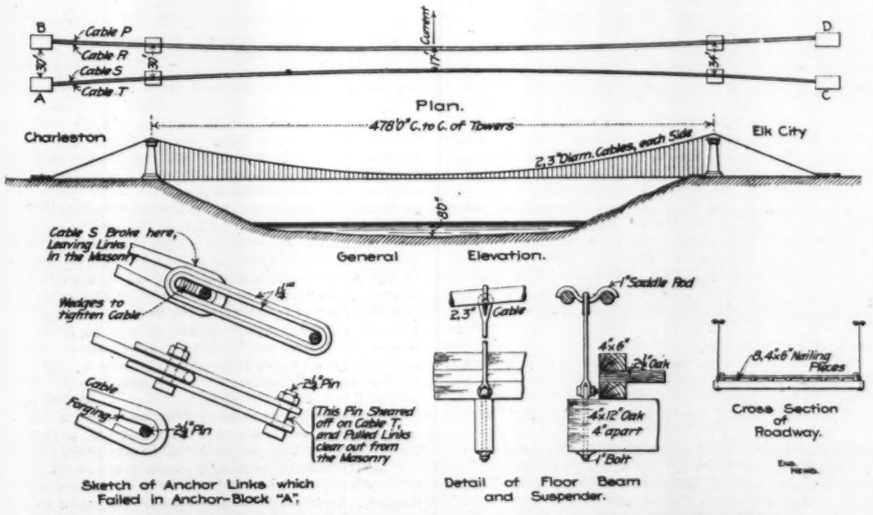
WRECK OF ELK RIVER SUSPENSION BRIDGE AT CHARLESTON, WEST VIRGINIA.

BROKEN CABLE OF CHARLESTON SUSPENSION BRIDGE.

each of these anchorages was protected by shelter houses, but in later years these shelters had been removed.

Under date of Nov. 17 the city of Charleston had sent out invitations to bridge builders for bids on repairing and reinforcing the structure. It was found that wires would frequently snap with a crack, and the broken end of the wire would curl out into the roadway. This condition alarmed the city into calling for repairs. In fact the bridge had been known for at least six years to be in a dangerous condition. Several times the bridge had been closed, but after temporary repairs it was again thrown open for travel.

There does not appear to be any authentic record of the size of the anchor blocks, and as they are almost entirely under ground it is impossible to tell at this time what condition they are in.



GENERAL PLAN, ELEVATION AND DETAILS OF ELK RIVER SUSPENSION BRIDGE.

The stone piers, as far as can be seen, are in good condition. They do not appear to have been injured by the fall of the rest of the structure.

The bridge does not appear to have had any wind laterals or other means of side bracing than the cradling of the cables.

The absence of stiffening trusses caused the floor to be very flexible, and under heavy loads its movement was always alarming, even though not dangerous.

A lesson from this disaster is to have all parts of the bridge so built that they can be easily and frequently inspected. The cables that failed were so inclosed in the anchor masonry that they could not be seen.

THE TRAIN ORDER SYSTEM AND THE BLOCK SYSTEM ON AMERICAN RAILWAYS.*

By H. D. Emerson.†

American railroads have in the past few years spent tremendous sums for improvements and betterments, but in one particular, on a large number of American lines, methods are in use that have not been improved for fifty years. Train dispatching, as practiced at present on our single-track lines and unblocked double-track roads, is undoubtedly responsible for the larger proportion of the casualties and a considerable cause of expensive wrecks.

The statistics of the Interstate Commerce Commission‡ tend to show that accidents are becoming more numerous on American railroads than formerly; that is, that the proportion of accidents to passengers carried is increasing. The Board of Trade reports for Great Britain indicate that in that country the reverse is true. Setting aside all academic discussions as to whether the Commission includes, in its comparative tables, passenger miles, train miles, total density of traffic or train movements, or makes sufficient allowance for the different conditions in England and America, the fact remains that it is not becoming progressively more dangerous to travel on railroads in Great Britain and that the opposite is true of America.

Admitting, then, for the purposes of this study, the contention that accidents are increasing in greater proportion than is the number of passengers in the United States, let us see whether we can indicate where at least part of the trouble exists. Let us see whether we can point out where improvements can be made which should, presumably, diminish the dangers of travel.

The Interstate Commerce Commission's table shows a total of 11,291 wrecks in the year 1904. Of these, 6,436, or more than 50% were collisions. The remaining 4,855 were derailments. The number of people killed by collisions was 630, and by derailments 368. By collisions were injured 7,083, and by derailments 3,161.

It is a matter of such common notoriety that all railroads are improving their plants and equipments that we can set aside derailments and assume that the cause for these is being corrected as rapidly as money, expended judiciously, can accomplish the result. Collisions, however, accounting for more than a total of one-half the accidents, were clearly the result of the method of handling trains. The men who handle trains to-day, that is, the trainmen and the dispatchers, are, on an average, the superiors of those who held the same positions ten years ago. This is a natural result of the scientific methods of examination and promotion which have been adopted. The conclusion is emphasized by a close acquaintance with the men themselves. That a small proportion of trainmen are inferior is also admitted, but the reasons for this can be briefly summed up in the single statement that railroad traffic development is continually increasing the number of men employed, and it naturally takes some time to weed out the incompetents among the new men.

It has become the standard practice that trainmen shall not be overworked as to hours. Engineers and conductors must have sufficient time for meals, for sleep and for recreation, and relaxation has been provided for. But although we may have reduced the average work day to 8 hours, have we not increased, and that very materially, the amount and kind of work required in the legal day? This point we will discuss fully in a later paragraph.

HISTORICAL.

The first railroads were simply highways, the flange-wheeled wagons that ran over them were drawn by horses, and the movement of these wagons corresponded to that of the stage coach. The invention of the locomotive, changed all this very materially. It became necessary to predetermine time and speed, and as soon as the traffic exceeded the capacity of one locomotive, meeting or passing point were also determined, and the first railway schedule came into existence.

Under this schedule two opposing trains were moved from the termini and run to a predetermined meeting point, and the first to arrive waited indefinitely for the other.

It is related that the first train directed by electricity in the United States was on the Erie Railroad. The superintendent of the Division was on the train which was waiting at a meeting point; the operator in the station told him that the opposing train was at a certain station down the road, and that its locomotive was disabled. The superintendent figured from the report he received that it would take several hours to make the repairs; so he issued the first train-order by wire, instructing the disabled train to wait at the station where the breakdown occurred, and ordered his own train to proceed. From this first telegraphic train movement was developed the American system of telegraphic train control. In effect, a system which was developed to meet an emergency, is now, without radical improvements, moving nearly all the trains on the single-track railroads of the United States.

In England the development was along radically different lines. Although for a time trains were moved on telegraphic order successfully, it was soon discovered that it was impossible for the superintendent or general manager to continue his personal supervision of train movements, and so, instead of delegating this vitally important matter to a subordinate, as is the American practice, English railroads developed mechanical means for the accomplishment of this result. At a very early date the proposition was laid down that absolute safety depended upon having only one train on a piece of railroad at one time; so the railroad was divided into sections, and a pilotman was appointed who convoyed the train back and forth over his section. Shortly afterwards the pilotman was replaced by a mechanical device—a block, which gave the name to the system, and which became known as

*Condensed from a paper read before the New York Railroad Club, Dec. 16.

†Vice-President and General Manager Darien & Western R. R., 5 Dey St., New York City.

‡See a review of these statistics in Engineering News of Oct. 27, 1904, p. 383.

"blocking," the device which was thereafter used being called the tablet or staff. From this beginning the block system developed to mechanically operated semaphores.

THE TRAIN ORDER SYSTEM.

A majority, in fact, practically all single-track American railroads, move their trains under the train-wire, or dispatcher system. Let us consider in detail train dispatching as it is at present practiced on a very short line, then on a larger line, and as applied to the congested division of a large system.

A small road, say 100 miles long, has been completed and is about to be operated with regular trains. The general manager and the superintendent prepare a schedule of the desired number of trains required to handle the expected traffic. Let us assume that the first schedule shows two passenger trains and one freight train in each direction per day. On the average road, 100 miles long, with stations five miles apart, the schedule will show twenty arriving times for each train. On the hypothetical lines, taking the average as we find them in the South and West, two passenger crews and two freight crews would be required. Each passenger crew will have a meeting and passing point in each direction, and each freight crew will have either two meeting and one passing or two passing and one meeting points. A meeting point is where trains going in opposite directions meet and pass, and a passing point is where trains going in the same direction pass each other. These meeting and passing points are the crux of the situation, for it is because of forgetfulness of the locations of these points that accidents happen. The superintendent prepares the schedule. It is handed out to the train crew, carefully studied, and, presumably, committed to memory. The road starts operations, and as long as all goes well and all trains are on time the train dispatcher has nothing to do but sit in his office and record the time as reported to him by the various agents.

Presently, however, one train is delayed. An accident has occurred to its engine, a bridge is out of order, a connection is late, or any one of a hundred reasons cause delay. Now, if the opposing train, or the inferior trains in the same direction, wait at the fixed meeting or passing point, they will be correspondingly delayed. The train wire is called into use and the dispatcher exercises his authority and issues orders, advancing trains by changing meeting or passing points. The conductor and the engineer receive duplicate copies of a brief, concisely worded telegram, telling them to forget one particular thing which they had been instructed to remember at peril of death, and to remember something entirely new and different.

I know that a majority of old engineers and nearly all train dispatchers will say that I am overstating the gravity of this situation. They have, by long process of training, become accustomed to doing things in a certain way, so that it does not require any conscious mental effort to remember certain things. One good friend of mine, in conversation recently, flatly contradicted my contention. He said that the train order did not require the engineman to forget anything, but simply gave him something more to remember. In other words, my friend's argument was that knowledge as to regular schedules, regular trains and all meeting points became more or less second nature with the engineman. Admitting that this is true, and it undoubtedly is, I desire to call attention to the fact that many wrecks are caused by men failing to do the accustomed thing, and that the two most expensive wrecks, gaged by loss of life in cost and damages, which have occurred in the calendar year 1904, occurred because the engineman and the train crews did the usual thing, and did not, as they were ordered, forget that which they had been previously instructed to do.

On the hypothetical road, with not to exceed four train crews, it is not a very serious matter to change a meeting point from Jayville to Bugtown, or to order a freight to run from Jones City to the terminus, ahead of and regardless of a passenger train going in the same direction. The train dispatcher is intimately acquainted with the road, with the agents, with the enginemen and with the conductors, and the agents and train crews also have an intimate acquaintance with each other. They are in daily touch, and each knows the peculiarities of his fellow-employees and has confidence in his carefulness, or takes due precaution against his possible negligence. Should an accident occur it is comparatively easy to fix the blame of the particular official in fault.

Let us consider the second proposition. Let us assume a railroad 300 miles long, operated in two freight divisions, with an average of five passenger trains and ten freight trains each way. Instantly the possible number of meeting points to be remembered rises from a maximum of four to a maximum of twenty-five for through passenger running over both divisions. The difficulty of committing to memory the complete time card in this case bears the same relation to the first as twenty-five does to four. The difficulties and entanglements resulting from delayed trains also increases in about the same mathematical ratio. The question of individual equation has, however, risen much faster than the increase in train traffic. The number of crews required in our first proposition will not, at the outside, exceed six; whereas in the second proposition it will rise to between 30 and 50, and the number of stations and station agents be increased from 20 to 60, to which must be added the required number of night operators. Further, it should be noted that the line will be put under the control of two dispatchers, who, each in turn, will be provided with trick operators, receiving and sending the messages to and from the agents. Here we have anywhere from 150 to 200 men who meet only occasionally, and who cannot acquire very much confidence in their fellow-employees by personal acquaintance with them.

Practically at this stage of the development the employee ceases to be individual. So far as the dispatcher is concerned, he becomes simply a man, known to do certain things, but who at any time may fail or forget. Not only is the dispatcher obliged to assume the knowledge, faithfulness and ability of agents, conductors and enginemen, but the enginemen and conductors also are obliged to make the same assumption with regard to their fellow-employees.

Under these circumstances, and as a result of accidents and experiences, a series of rules has been developed, which in its best and smallest form is the Standard Code, as adopted by the American Railway Association. This code has 23 rules and 13 forms especially applicable to single-track operation, all of which must be committed to memory by every dispatcher, agent and trainman. These rules are the result of the experience of all the railroads in the United States represented by the Association which developed them. It is being daily demonstrated on many railroads that if these rules are understood perfectly and followed implicitly by conservative, well-disciplined employees, trains will be handled practically without wreck. There are many particular pieces of railroad in the United States which can be selected to prove this fact. There are many train dispatchers with honorable records of many years' service who have never lost a life, and who cannot properly be held even indirectly responsible for damage to property. But it is the question of discipline and education. The very fact that dispatchers differ as to the best method to be used and that the same rules on two different roads in the United States produce two entirely different results, is evidence that they can be improved at least. On one, trains are handled with a high degree of safety; on the other, wrecks continually occur. I would be the last to deny to the great body of train dispatchers due credit for the good work they have done; and American travelers and American railroad stockholders have cause to appreciate the system in the result which it has produced.

But to return to the illustration in hand. All these rules should be committed to memory by every dispatcher, agent and trainman. Not only must these rules be committed to memory, but they must be so absorbed that the individual may know which particular rule applies to any particular situation. Each individual must also know exactly what each order means, and how to interpret that order under varying circumstances. Here, then, is the situation. The engineman receives the predetermined schedule, showing the times and meeting places. He has his rule book and, presumably, has received instruction thereon. Having passed an examination as to his competency as a mechanic, having made sufficient trips over the road to learn the line, he takes a train. The time of departure arrives. The train is made up, the passengers are aboard, the conductor gives the word and the train pulls out. Curves are succeeded by tangents, grades by declivities, and the engineer is constantly engaged in handling his locomotive so as to make the speed required by his schedule and yet consume only the minimum amount of fuel and supplies. In addition to continually doing things on and with his engine, signalling crossings, watching for bad spots in the track, easing up for curves and noting dangers ahead, he must consider the schedule; that is, he must take note not only of the time the train is due at each station, but he must keep in mind when all other trains are due at stations ahead. He assumes that all other enginemen are following the schedule and the same rules, and so runs along, assuming that everything is all right, until he is notified that something is wrong.

This notification, so far as train dispatching goes, comes in the form of a telegram, advising him that he can run past a certain meeting point, but may expect to find at "B" the train which should have been at "A." Where his own train is on time and the other trains are late, the engineman may run his entire division with only one order to forget that which he had so carefully learned and to remember something else. But let us assume that his train is delayed; that he is obliged to wait at the junction point one hour and twenty-three minutes for an important connection. While our engineman is waiting, the dispatcher has advanced opposing trains—that is, has given them orders to run, neglecting the proper meeting point for our friend's train. When, however, the belated connection arrives, our friend then gets orders to proceed, the order naming new meeting points and new passing points, which, in the proposition under consideration, might mean as many as 25 changes in a 300-mile run. These orders are not all delivered to him at once, unless, perhaps, he gets what is known as a "run-late" order; that is, an order directing him to run on a schedule one hour behind his regular time. In this case he proceeds to transform himself into a mathematical expert and ure out the meeting points of trains of his own or a rior class. Inferior trains are, under the rules, su to look out for themselves.

Now, what is it that the dispatcher is asking the crew of this belated train to do? These men have taught certain rules and certain instructions, all of center in a printed time table. He is asking them, dition to performing the usual duties of enginemen men or brakemen, to forget suddenly and instantly most vital and important lesson which they have lea and to substitute for it a new lesson, to perform a memory feat at peril of their lives. This is unquestio the greatest weakness of the train-dispatcher's syste is the over-loading of an already busy brain. This is ing the man to sprint his distance in athletic compe and at the same time memorize his mathematical fo las—and not only memorize them, but put them into while running.

But how about the opposing train? Suppose our sp ter does his running, commits his formulas and work his problem without error? He must assume that his posing fellow-servants are equally correct, equally curate and equally infallible.

But I have not noted two other chances for error. agent, or, in a case of duplicate orders, each of the ag receiving the orders may make a mistake in transcrib or he may fail to deliver; so there are two chances of ror to each agent. It is true that these chances have b minimized by repeating back, by middle order and o precautionary measures, but they still exist.

And last, but not least, what of the dispatcher? H many mathematical sharps will agree to take a dispatcher's record sheet, half completed, where each umn is developing at a different rate of progression, guarantee, in the shortest possible time and under the heaviest possible pressure, to determine accurately wh each irregular progression will cross the other prog sion, or where each will coincide? Yet this is what train dispatchers are supposed to do; what, in fact, they are doing daily. The chances for error in the dispatcher's office have been materially minimized by the improved rules, so that at this time it requires extremely bad judgment or gross carelessness to cause a collision which can be traced to this fountain head. But men are fallible, and in the press of business and the desire to expedite the movements of trains mistakes have crept in, and will continue to creep in. Many a train dispatcher has had cold perspiration when he realized that two trains were speeding towards a collision point as a result of his unintentional omission or inadvertent act. I cannot do better in gaging the chance of error in the train-dispatcher system than to quote one of our prominent managers, who says that the average length of service of a dispatcher is about seven years: "Some get them together in three months, and some not for twenty years," meaning, of course, trains in collisions.

But what of our third proposition—a single-track main line, leading to the terminus of a large system? One illustration will be enough, I think, to show the unwisdom, to say nothing of added cost and overtime, of attempting to operate this kind of a line on dispatcher's orders. Within the year, after riding all day on a fast express train on a certain trunk line, we came to the last freight division before arriving at our destination. At or near this point several branches join the main stem, and this particular division, about 100 miles long, has forty regular schedule trains in each direction, nearly all of which run beyond the jurisdiction of this particular dispatcher. Our train was some two hours late, and in addition the whole schedule was very badly disarranged. At nearly every side track we met or passed a train. I do not know how many trains in the 100 miles, but it would be safe to say between twenty and thirty. At nearly every telegraph station new train orders were received. In one instance one operator delivered as many as five different orders affecting our train. At the end of the run, after we had arrived in the depot, I asked the engineman how many orders he had received on the last division. He handed me his tissues and I counted them. I am afraid to give you the number, because if I did I am sure I would be accused of exaggeration. Train dispatchers can approximate the number of tissues I received by figuring how many different orders an active, energetic man can send, under the rules, in about three hours. I think this particular dispatcher broke the record for the number sent. I do not believe he will break any more records on this road, for I understand he was removed shortly afterwards. I know this is an extreme case, and I know also that this was extremely bad dispatching. The division was very much congested, and the company was handling much more traffic than its facilities could reasonably be expected to provide for. Personally, as a passenger, I know that at the end I offered up a little prayer of thanksgiving to the Divine Providence which cares for American railroad men, that we had come safely through the mess.

The point I desire to bring out is that, at its best, train dispatching, as practiced, has elements of danger in excess of two to one at four different points, and that at its worst the chances of wreck are simply terrifying to those who understand the possibilities.

is a tribute to the faithfulness, the mentality and the training of all connected with all train movements that works are as few as they are under this system. If our enginemen are able to do well under a system which demands that they "assume they are right and run until notified different," how much better would they do under a system which is theoretically correct and has for fifty years been worked out with a continually decreasing number of accidents; a system like the English block system?

THE BLOCK.

After the traffic on the railroads in England became so congested that it could not be moved under the simple time-schedule arrangement, two methods were developed. The first is what is now known as the Tablet or Staff system. Under this arrangement the railroad was divided into sections or blocks, and each block was controlled by a tablet or staff. The engineman ran only when he had in his possession the staff which belonged to his particular block. This worked out so that the trains must be equal in number and must pass each other. That is to say, when a train was going north and the staff had been moved to the north end of the block no other northbound train could enter that block until the staff had been returned to the south end of the block. From this worked out the staff and automatic system whereby the agent at the end of the block retained the staff and gave to the engineman a ticket which permitted him to pass through the block. This provided that when a number of trains were moving consecutively in the same direction the last train carried the staff to the other end. This system developed some of the same dangers as the train dispatcher or time system and resulted in rear-end collisions.

To obviate this difficulty and permit the freer movements of trains, the staff or tablet system was developed. This provides for a box with a simple mechanical device at each end of the block, the two being electrically connected. Each box contains from ten to twenty tablets, or staffs. When one tablet or staff is removed from either box, both boxes are locked and no more tablets can be removed until the one in hand has been returned. Under this system the engineman knows absolutely that he has the sole right to the piece of track or block covered by the tablet or staff in his hand.

As traffic increased manual blocking was adopted, first on double-track roads and later on single-track roads. This system provides for an electric bell connection between the signal box at each end of the block. As the train approaches signal box "A," the signalman calls box "B" and notifies him that a train is approaching and asks his permission for it to enter the block. If the permission be given, signalman "A" lowers his semaphore and allows the train to enter the block, at the same time notifying signalman "B." After the train clears the block signalman "B" records its passage and is then prepared to admit the next following train. This system, slightly modified, has been applied to single-track blocking in both the United States and England. It is also modified by locking the semaphore so the signalman "A" has no control over his signal until it is released by "B."

There are objections to the block system. The principal argument against it is that it delays, or is likely to delay trains. If a wreck occur or a train be retarded in its progress and sufficient trains follow, within a certain readily determined time it is possible to have every block in a division occupied by a train. The answer to this objection is twofold. First, it is better to delay trains than to have wrecks; second, if the block length be properly calculated, and the system properly operated, such delay will occur only when it is desirable—that is, when the schedule becomes disarranged as a result of some untoward cause.

Another objection which is occasionally raised against the block system is that wrecks have occurred where it has been in use. I think a sufficient answer to this is that anything devised by man will prove defective at times, and that statistics show that wrecks are of less frequent occurrence on blocked lines than on lines operated under the dispatcher system. But even with the block system a difference should be noted. Collisions are of much more frequent occurrence under the block system in the United States than under the block system in England.

In England, with a much smaller mileage and a greatly denser traffic, fatalities are much less, proportionately, than they are in the United States. Is this not because the training of the engineman in the United States and the training of the engineman in England has been radically different? An English engineman has practically nothing to do with telegraphic orders. Before entering a block, and even before starting his train from a terminus, he knows definitely that the block is clear. He expects to be told by the indications of the signal: "All right. Go ahead."

In operating on a single track with the tablet or staff system the very act of obtaining possession of the tablet or staff conveys to the English engineman a definite knowledge that he has the right to proceed. On the other hand, the American engineman has been educated to start his train on schedule time and to run and to look and to assume that everything is correct until he is told differently. Is it not true that his mental attitude of assuming that the signal will be clear when he shall reach it and that everything is right, causes many wrecks? If in each instance the engineman approached the block signal in a receptive frame of mind, expecting it to be against him and not passing it until he was definitely assured that it is not, would not a large percentage of the accidents which occur on blocked tracks be eliminated? The use of the staff system absolutely does away with the necessity of remembering orders or even of remembering the position of the signal at the end of the block. With the staff or tablet the engineman carries the signal with him, and he cannot only look at it and determine whether he has a right to be where he is, but he can also show it to others if he is called upon to prove his position.

If a railroad company has ample funds and the question of primary cost or annual maintenance does not enter in, then the automatic block, as adopted by a number of roads, is the safest and best. But in at least 50% of the mileage in the United States the question of primary cost is of eminent importance. In advertising changed methods of train dispatching, we must show: First, small primary investment; and, second, no increased cost of operation or maintenance; and I believe that the answer which completely fills the situation and which will meet many conditions is the tablet, or train-staff system. The theoretical requirements of the tablet system are: First, that the railroad be divided into blocks of convenient and proper lengths; second, that each block have two instruments, one at each end, electrically connected, so that when a tablet is removed from either, both instruments will be locked until the tablet is returned and inserted in one or the other instrument. That on a railroad division equipped in this manner dispatchers and operators could be dispensed with, and that if the engineman follow the single rule that they must never run through a block unless they are in possession of a tablet for that block, wrecks would not happen, is true theoretically and has been demonstrated by practice.

It is conceivable that at times trains might be delayed, but on the other hand it is admitted that, given a schedule with a train density as outlined in our second proposition in discussing the dispatcher system, the average movement of all trains would be expedited.

For a light traffic road with few high-speed trains, tablet machines which will cost less than $100 per mile can be installed. The length of the block can be made to coincide with the average stop of trains—say every six to ten miles. With this system the tablets of adjoining blocks are of different sizes and shapes, so that an engineman or motorman can not make a mistake by placing a tablet in the wrong machine. On roads with denser traffic, more effective and more complicated devices have been designed. For high-speed trains arrangements for delivering and receiving the tablet without delay have been devised. In another system overlapping blocks have been arranged, so that freight blocks might average five miles in length and express passenger blocks thirty miles. In fact, machines have been devised to put the theory into practical operation under every conceivable condition of train operation. Conditions as to cost can be made variable to coincide with the density of traffic. Maintenance of the staff system costs little more than to maintain a telephone line. Safety and effectiveness are at a maximum. Complexity of rules is eliminated. Division of responsibility is done away with and a device, a piece of metal, is substituted for more or less imperfect memory. But best of all, the theoretical training and the primary instruction of the trainman is changed from "assume you are right and run until you find different," to "be sure you are right, then go ahead."

If you ask, if single-track blocking is satisfactory and works for safety, why are so few of our lines blocked, I answer: There are two reasons. One is that only within the past few years has the train-dispatcher system reached the breaking strain. Included in this is the disinclination of many managers to adopt anything different. Then, too, many managers have been impressed with the idea that the block system necessarily means expensive installations. The second important reason why we have not had mechanical devices similar to the English tablet machines is that the American manufacturers of railroad appliances have had their attention turned more towards interlocking and automatic signalling than towards the simpler and less expensive devices.

Right at this point I would like to call the attention of engineers, inventors and enterprising manufacturers to the desirability of designing and placing upon the market an inexpensive tablet machine. Almost any electrical engineer or telegraph superintendent can design and construct in his own shops a tablet machine which will answer all the requirements of the ordinary railroad with moderate traffic. For example: A wooden box, the size of the ordinary long-distance telephone box, containing two dry batteries, with a spring plunger mechanism and negative and positive contacts, large enough to contain twenty brass plates, with an outwardly opening door locked by a small double-pole telegraph relay coil, connected with its mate by a single No. 9 wire, will make a much better blocking device than any I have seen in the United States on any of our electrical railroads, and could be installed on many of our minor trunk lines to great advantage.

My own conclusion is that, theoretically, for single-track roads the tablet or staff system is far ahead of anything else which has been suggested. The cost of installation and maintenance is not greater than that of the manual block, considering the device that is at present in the market. If a cheaper device be utilized, of the English form, or if the signal department manufacture its own tablets and boxes, the cost of installation would be less. And, most important, the staff itself, the thing, is the most potent rule and the greatest insurance of safety that has ever been suggested. Engine drivers must, of necessity, be more or less skilful mechanics. They deal with things. To start the train they take hold of a thing—the throttle. To stop the train they take hold of another thing—the handle of the hand-brake valve. To blow the signals, or ring the bell, they touch other things; and so through their entire life they are trained to the use of things; and if you give the staff to them they have the ever-ready physical evidence of their right to the track. If you ease the burden of an engineman's mind and relieve him of mathematical calculations he will be able to devote more time to the mechanism under his charge and to get better results from it.

RECENT EXPERIMENTS WITH MATERIALS WHICH RETARD THE ACTIVITY OF PORTLAND CEMENT.*

By R. C. Carpenter,† M. Am. Soc. M. E.

In many instances the setting of Portland cement, which is the initial process of hardening, takes place so rapidly as to present practical difficulties in the proper gaging and use of the cement. To overcome these difficulties it has been customary for many years in the manufacture of Portland cement, to mix with the cement some material which would retard the formation of the crystals of aluminate of lime and similar compounds, and thus regulate the time of setting. For this purpose, gypsum, (sulphate of lime ($CaSO_4$), has been principally used. The effect of adding gypsum is only temporary, provided the cement is exposed to the air, and for that reason other materials have been sought for. The present article gives a brief description of some experiments made in the Mechanical Laboratory in 1904, by Walter H. Kniskern and William L. Gass, for the purpose of determining the regulating power on setting of cement of gypsum and chloride of calcium ($CaCl_2$).

For the purposes of the experiment, one of the large Portland cement works supplied us with clinker which had not been treated and which in its normal condition made a remarkably quick setting cement. This clinker was ground in a pebble mill owned by the Laboratory, under conditions which permitted the addition of the various materials to be tested.

The following shows in tabular form the results of adding different amounts of gypsum, the gypsum being proportioned by weight, as indicated in the first column of the table. In these experiments the time of initial set is taken in every case as the time when a pat of the cement made by mixing with the percentage of water shown, would bear a rod with diameter of 1-12-in. carrying a weight of ¼-lb. The time of final set is taken as that time which has elapsed since mixing, when the pat will bear a rod 1-24-in. in diameter carrying a weight of 1 lb. This method of determining the set, although commonly used, depends to some little extent upon the judgment of the operator, and as would naturally be expected gives results which are somewhat irregular although sufficiently accurate for purposes of comparison.

The results of the trials referred to with gypsum show that 1½% produce the maximum effect in retarding the set, and that for the special samples tested no beneficial results were obtained by the use of a large amount.

The following table shows the retardation of the set due to using different quantities of gypsum:

Per cent., $CaSO_4$	Per cent., water.	Initial Set. Mins.	Final Set. Mins.
0.0	29.8	2.0	52
0.5	27.6	6	87
1.5	22.1	80	157
2.0	22.1	24	114
2.5	23.7	29	79
3.0	22.1	30	69
3.5	22.1	27	72
4.0	24.2	28	45
4.5	25.4	22	40
5.0	25.4	27	59
5.5	25.4	20	78
6.0	24.2	19	37
6.5	23.7	22	40
7.0	25.4	18	59

Although the experiments above show that a maximum retarding effect was produced by the sulphate of lime when less than 2% was ground with the clinker, it is quite certain from previous experiments that with Portland cement of different composition or having been burned differently, more gypsum would have been required for maximum effect.

Experiments made by Candlot and verified in the Mechanical Laboratory of Sibley College indicate that an addition of 2 to 4% of slacked lime or hydrate of lime added to a cement containing a small percentage of gypsum,

†Professor of Experimental Engineering, Sibley College, Cornell University, Ithaca, N. Y.

*Extracts from the advance sheets of the "Sibley Journal of Engineering."

which has through the influence of time lost its effect in retarding the cement, will restore the slow setting properties.

	Time of set Initial. hr.	m.	Final. hr.	m.
Cement containing 2% of gypsum	0	20	2	30
Same cement to which has been added 2% of lime	6	0	10	0
Cement containing 1% of gypsum	0	10	0	20
Same cement with 2% of lime added	1	0	8	0
Test made in Sibley College laboratory of sample.				
Containing 2% of sulphate	0	12	0	15
Same cement with 5% of lime hydrate added	2	0	5	0

From 2 to 5% of lime hydrate will be found useful for retarding the setting of cement to which gypsum has been added but which has lost the effect. The additional lime does not detract from the strength, as in the case of the last-named cement its initial strength, neat, was as follows:

24 hours	390 lbs.
1 week	757 "
1 month	871 "

The addition of hydrate of lime without the addition of the sulphate of lime, seems to have little or no effect on the time of setting, as shown by experiments made by Kniskern and Gass.

The investigation of E. Sandlot, as recorded in his work on "Ciments et Chaux Hydrauliques," shows that when Portland cement is gaged with a feeble solution of chloride of calcium, it has the effect of greatly retarding the time of setting, but when the Portland cement is gaged with a concentrated solution of chloride of calcium, as for instance 100 to 400 grammes per liter, it acts in a contrary manner and tends to increase the rapidity of setting.

Messrs. Kniskern and Gass, in the Sibley Laboratory, ground different percentages of chloride of calcium* with cement clinker and afterwards made pats, using in each case simply enough water to give the material its normal consistency for this purpose. Their results show that the chloride of calcium had great effect in retarding the time of setting and exerted the greatest effect when about 0.5% by weight of the chloride of calcium was employed. On account of the water required, 1% of the chloride of calcium would correspond approximately to gaging with a solution of 30 grammes per liter in the previous experiments quoted.

$CaCl_2$ GROUND DRY WITH THE CLINKER.

Per cent. of $CaCl_2$.	Per cent. of water.	Initial set. Mins.	Final set. Mins.
0.0	23.8	20	52
0.5	34.1	115	274
1.0	29.8	160	272
1.5	26.4	167	234
2.0	25.4	127	212
2.5	26.4	103	180
3.0	26.4	45	182
3.5	26.4	97	185
4.5	28.6	63	150
5.0	29.8	73	160
5.5	29.8	76	84
6.0	29.8	68	145

The experiments quoted indicate that chloride of calcium added in small percentages either to the ground clinker as a powder or mixed with the water for gaging, has an important effect in extending the time of setting of Portland cement, and so far as the investigations which are accessible show it does not have any detrimental effect on the permanent strength and hardness.

Chloride of calcium is a deliquescent material which rapidly absorbs moisture, and it is possible that if ground dry with the Portland cement clinker, even to the amount of ½%, it would cause the material to gather dampness and thus have a bad effect. The chloride of calcium solution can be added readily by adding it to the water used in gaging since it dissolves with extreme rapidity. The experiments indicate that the set can be controlled by using less than ½%, which would be something less than 2 lbs. to the barrel of Portland cement. Investigations are still necessary for determining whether the effect of chloride of calcium added to the cement before grinding is permanent in its effects, and whether if ground with the cement clinker it would avert any detrimental effect.

*Supplied by the Carbondale Chemical Co.

AUTOMATIC WATER PIPE SCRAPERS AT MELBOURNE, AUSTRALIA.

The removal of incrustation from water mains has never become an established practice in the United States, as it has in Great Britain and her colonies. A paper describing an exceptionally compact automatic scraper used during the last few years at Melbourne, Australia, has just reached this country.†

†Methods for the Removal of Incrustation in Water Mains, with a Description of the Automatic Machine Employed in the Melbourne Water Supply." By Edgar Gowar Ritchie, Assoc. M. Inst. C. E. Excerpt Proc. Inst. C. E., Vol. civil. (1903-4), Part III. The paper is devoted chiefly to Melbourne experience.

On p. 45 of Engineering News for July 20, 1899, there appeared a descriptive list of the principal literature of this subject, since 1880. The list accompanied an article on "Cleaning Cast-Iron Water Pipe with Scrapers at St. John, N. B., and Boston, Mass." Subsequent articles in Engineering News have been as follows:

July 27, 1899: A continuation of the last-named article.

Aug. 23, 1900: A summary of experience with mechanical scrapers at Halifax, N. S., from 1880 to 1898.

Aug. 30, 1900: "English Practice in Cleaning Water Mains with Scrapers and Brushes," an abstract of a paper by Mr. Wm. Ingham, Borough Water Engineer of Torquay, England, read before the Institution of Mechanical Engineers (London) and reprinted in both "The Engineer" and "Engineering," the latter for Nov. 3, 1899. The original paper related chiefly to experience at Torquay, but was supplemented by a discussion, which we abstracted, relating to the use of scrapers at Liverpool and at Sheffield.

An earlier paper, not heretofore noted by us, was as follows: "The Removal of Internal Corrosion from the Mains of the Kendal Water-Works," read by T. N. Ritson before the British Association of Water-Works' Engineers" and abstracted in the "Journal of Gas Lighting" (London) for Aug. 3, 1897.

The author of the paper, Mr. E. G. Ritchie, Assoc. M. Inst. C. E., as assistant engineer under Mr. W. Dowden, Superintendent Engineer of the Melbourne Water-Works, had charge of the trials which led to the design and use of a scraper differing materially from any which have previously come to our attention. Unfortunately the paper does not say why this scraper is so unlike those used elsewhere, except for the statements that the incrustation is soft and that the aim was to produce a scraper adapted to the pipes of a distribution system down to as small as 4 ins., to pass bends of 9 to 12-in. radius, and also projecting ferrules of house connections, and to work under water pressures as low as 20 lbs. per sq. in. The

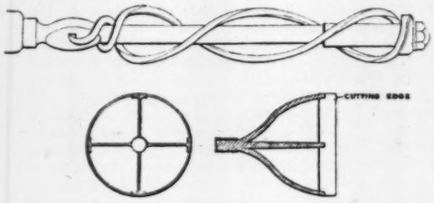


Fig. 1. Hand-Scrapers for Cleaning Water Mains.

sections and accompanying information given herewith seem to show that the scraper is eminently successful.

In the opening part of his paper Mr. Ritchie makes some remarks on incrustation which we quote in part, as follows:

> The character of the incrustation varies according to the quality of the water, being softer and forming more rapidly in waters containing much vegetable matter. In pipes which have been coated in the usual manner, the incrustation is generally found at the outset in small tubercules occurring at intervals on the internal surface, wherever the coating is weak or has become damaged; in course of time these extend, until finally they completely fill the pipe. In pipes which have either not been coated before laying, or have once been cleaned, the growth takes place regularly all round the pipe and much more rapidly. This incrustation is generally most troublesome in the smaller pipes (3 ins. to 6 ins. in diameter), but in course of time the larger pipes are also affected.
>
> Annoying discolorations of the water are sometimes caused by the dislocation of the incrusting matter. Although Dr. Angus Smith's pipe coating lessens corrosion, it is
>
> only efficacious for a term of years and it therefore follows that to maintain both the quantity and the quality of the supply periodical removal of the incrustation is absolutely necessary. It should not be allowed to grow until it causes serious chokage, and expense in removing. The pipes must be attended to regularly and systematically.

Hand scraping was practiced at Melbourne for a number of years before the automatic scraper here described was adopted, and has since been employed for short cross-connecting pipes, hydrant branches and presumably for pipe smaller than 4 ins. in diameter. Of the two hand scrapers shown in Fig. 1, the spiral scraper, A, was tried in 1894, but was not as satisfactory as the cylindrical scraper, B, already in use, "probably owing to the fact that the incrustation is fairly soft and crumbles readily." The spiral scraper "has been successfully used in a more or less modified form in some of the other Victorian town-supplies and in Sydney." The cost of a single Melbourne cylindrical scraper is about 10 shillings, or some $2.50. Some figures of cost of use are given at the end of this article.

The automatic scrapers are described in the paper as follows:

> The machine which has been adopted in the Melbourne water-supply is known as the "Bilton" automatic scraper. It consists of two pistons, each carrying tumbling "cutters," and it differs from others of its class in the combination of piston and scraper in one (Figs. 2 and 3)*. The tumbling cutters support and take the wear off the piston disks, which retain the water and thus secure the necessary pressure to drive the machine. The latter, by reason of this arrangement, so gains in compactness as to be capable of passing ordinary obstructions, of going round bends, and of being inserted in and withdrawn from a very short opening in the pipes. The pistons are attached to a short spindle, and each carries a ring, securely fastened in a groove at the back, upon which are threaded the tumbling cutters. The latter, besides being attached to the ring, are contained in and guided in their action of tumbling by radial grooves cut in the metal pistons. Immediately behind the cutters are disks of best English leather or rubber insertion cloth. Next to these are red rubber disks, which are held by a metal washer and adjusting lock nuts on the spindle. The disks and red rubber allow the cutters to be depressed when an obstruction, such as a ferrule, is met with, and, in the front piston, act as a cushion to force them back again to the full diameter of the pipe, the pressure of the water fulfilling this service in the back piston. By means of the adjusting nuts the cutters may be slackened or stiffened in order to deal with pipes of slightly different diameters. Further, it is often necessary, where the incrustation is heavy or of a hard nature, to remove it in two or three scrapings, screwing up the cutters by means of the adjusting nuts, after each operation, until the pipe has been cleared out to the full diameter.
>
> The movement of the machine through the pipe is practically without rotation, the spiral lines of the cutting edges of the front and back cutters being divergent, as shown in Fig. 3. The cutters cling to the internal surface of the pipe and remove the incrustation in a far more complete manner than a hand scraper, which has to be of slightly smaller diameter than the pipe in which it works. Further, the result is attained without damage to the coating, which remains intact with the marks of the cutters just visible on it. It will be seen that from the nature of its construction, the machine cannot be driven backwards. The front piston is set in relation to the back piston so that the cutters of the latter traverse the surfaces untouched by those of the former. The action may best be described by stating that the work of the front piston results in the incrustation being "ploughed up" as by a plough share, whilst the function of the back piston is to grind up and remove what is left. The water under pressure escapes in a fine stream at high velocity around the circumference of the disks, and, playing immediately upon the cutting edges, flushes the deposit away ahead of the machine to hydrants, scours, or other openings. In the smaller sizes, especially 4-in. and 5-in., the disks of the back piston must be cut to the full diameter of the pipe, otherwise it is impossible to obtain sufficient pressure on the machine to drive it through the pipe. It is found that the water which escapes past the disks is ample for securing purposes. The disks of the front piston are necessarily smaller than those of the back piston, in order to prevent the machine becoming choked with deposit. Pipes corroded to such an extent that the clear diameter left is much less than that of the solid portion of the front piston, e. g., a 4-in. pipe in which the

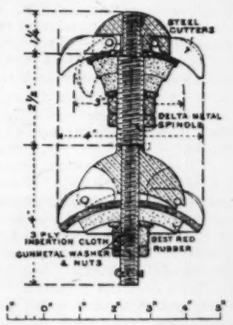


Fig. 2. A 4-in. Bilton Automatic Water Pipe-Scraper Used at Melbourne.

clear bore is less than, say, 1½ ins., cannot be cleaned by this method, but must be cleared out by hand scrapers for short cuts.

The author contends that incrustation should never be allowed to accumulate so as to obstruct the discharge to this extent, but should be systematically removed. It has been found, however, that by using scrapers of increasing sizes, say, 3½, 4, 4½ and 5-in., and sometimes slackening the adjusting nuts, a pipe very much corroded can be effectually dealt with by repeated scrapings. In machines of the larger sizes, since there is a superabundance of driving power, owing to the greater piston area, it becomes possible to increase the scouring action very considerably. This is affected in the 12-in. machine by a number of holes bored in the hollow spindle, directing jets of water on to the front cutters, Fig. 3. These were found very serviceable in heavily incrusted pipes, where

*A section of a 6-in. scraper is given in the paper. It closely resembles the 4-in. scraper shown here.—Ed.

there was a great quantity of sediment to be removed. They may be closed by means of plugs during a second scraping, so that the scour may be confined to the outside edge of the disks. In the 9-in. machine a safety valve was provided, to act when the pressure rose to 80 lbs. per sq. in. This provision was considered to be necessary in case of a sudden stoppage of the machine giving rise to a "water ram," and thus causing damage to the pipes; but the relief afforded by the opening of a 1-in. jet in a 9-in. pipe, or a 1½-in. jet in a 12-in. pipe, would not be very great if the pressure rose to, say, 200 lbs. per sq. in. It was found that with judicious use of the pressure, so that the passage of these larger scrapers was never forced, there was no necessity for a safety valve, an appliance the utility of which is further liable to be restricted by its becoming choked with sediment.

The speed of working of the machines should not exceed four miles an hour, depending upon the amount of incrustation in the pipes, and the best result is obtained by limiting the speed to two miles an hour. In the larger sizes, with a good pressure, a very small opening of the regulating valve is sufficient; the slow speed not only allows the scraper time to do its work and prevents it becoming choked with sediment, but also enables the foreman in charge to accompany it on foot and note its progress.

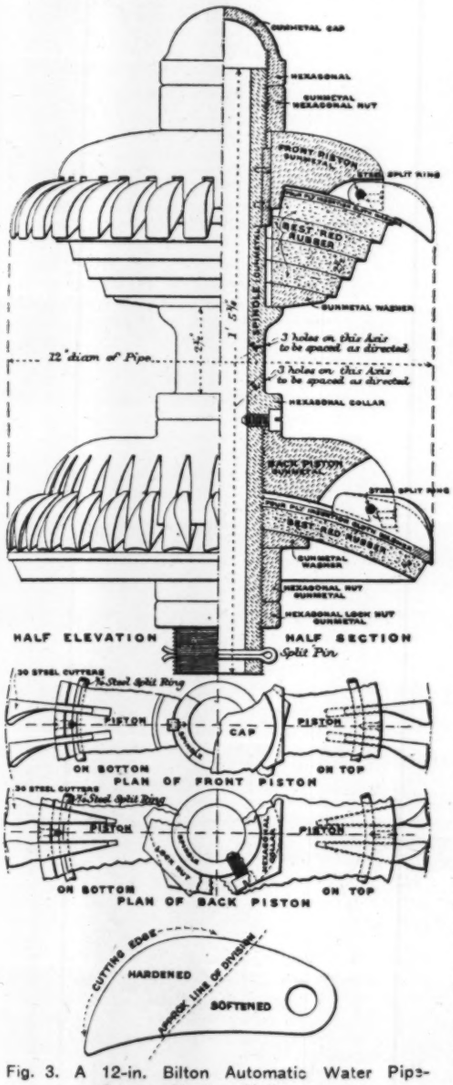


Fig. 3. A 12-in. Bilton Automatic Water Pipe-Scraper Used at Melbourne.

The average cost of the machine is:

Size.	£	*$
4 ins.	12	60
5 "	15	75
6 "	19	95
9 "	35	175
12 "	65	325

*Approximately.

As the number of 7-in. and 10-in. pipes in the Melbourne system is comparatively small, a saving was effected by utilizing for scraping these, the 6 and 9-in. machines respectively, the cutters of the latter being temporarily replaced by larger cutters, with stiffer packing and insertion disks behind them.

The pistons of the 4-in. and 5-in. machines are of "delta" metal, muntz metal, or phosphor bronze, a very tough material being necessary for the webs between the grooves for the cutters, especially in the front piston where the webs are very thin in order to gain thickness in the steel cutters. Breakage of the cutters takes place most frequently at the outside edge of the piston, where the cutter is enclosed in the groove. The cutters are made to fit accurately, without undue play, and to be interchangeable in the grooves. They are thus readily replaced by the foreman if they break during the operation of scraping. The cutters, which are of cast steel, are tempered glass-hard on the cutting edges, the web portion contained in the grooves of the front piston being softened to prevent brittleness at this point (see detail, Fig. 3). They are stamped out by dies in the rough, and ground to size on an emery wheel. In the 12-in. machine, which is the most recently constructed, the adjustment of the foremost piston is effected from the front. This is more convenient for the removal of the piston from the spindle, in the event of a cutter breaking, than the adjustment from behind used in the smaller machines. This arrangement is impracticable in the smaller machines, since the round nose of the front piston must not be sacrificed (this feature being essential in the traversing of bends), nor must the machines be unduly lengthened, and the front cutters must be kept as far forward as possible.

Cross-connecting pipes less than about 900 ft. long and dead ends less than 500 ft. in length are cleaned by hand scrapers. In small pipes provision for flushing out the dislodged incrusting material should be available at intervals of 200 to 330 ft. Fire hydrants will serve this purpose.

Hatch boxes for inserting and removing the scrapers must be provided. In small mains these may be used as washouts by supplying discharge fittings. The length of hatch boxes ranges from 8 ins. for 4-in. pipes to 15 ins. for 12-in. pipes.

Between August, 1897, when the machine was first used at Melbourne, and the end of June, 1902, 164 miles of mains have been cleaned by it. A good week's work, on a distribution system, for a gang of six men is 170 chains, or 11,220 ft. Rates of wages per hour at Melbourne are as follows: Foremen and jointers, is. 3d., or 30 cts.; laborers, 10½d., or 21 cts. Inasmuch as the figures of cost of cleaning given below include materials, the unit prices of these are also given: Cast-iron pipe, $42 per (long?) ton; specials, $53 per ton; lead, $68 per ton.

The costs of cleaning reported have been reduced from shillings and pence per chain to cts. per ft., and are as follows:

(1) 21 miles of reticulation pipes of all sizes from 4 to 9 ins.: Labor, 0.34 to 1.1 cts. per ft.; material and cartage, 0.3; average total, 0.77-ct.

(2) 19 miles of 4-in.: Average total cost of cleaning, 0.75-ct.

(3) 4,488 ft. of 10-in.: Labor and cartage, 0.6-ct.; material, 0.37-ct.; total, 0.97-ct. (Two cuts were made.)

(4) 3 miles, 792 ft. of 6-in. pipes, circumstances favorable: Labor and cartage, 0.14-ct.; material, 0.04-ct.; total, 0.18-ct. (Two cuts were made.)

(5) 2 miles, 528 ft. of 12-in. pipes: Very heavily incrusted; many obstructions encountered; route entirely through very thickly populated districts connected by branch pipes to the 12-in. main; many stoppages in the old service pipes not provided with stop taps; cost of labor and cartage, 1.96 ct.; material, 0.27-ct.; total, 2.23 ct. (Six cuts were made.)

(6) 3 miles of 12-in. 3,630 ft. of 10-in., and 1,046 ft. of 9-in. pipes, through thickly populated districts: Labor and cartage, 0.64-ct.; material, 0.5-ct.; total, $1.14 ct. (Six cuts were made.) During this run the machine at one point traveled 30 to 40 ft. vertically, thence about 160 ft. horizontally, thence returning 30 or 40 ft. vertically, besides passing four right-angle bends. The pipes were of wrought iron, riveted, and were carried across a river by a large railway bridge. In two places the machine traversed deep and wide railway cuttings, successfully passing each of the sharp bends, the pipes being laid under the line. At all these points hand scraping would have been very difficult and costly to carry out.

(7) 6 miles 4,752 ft. of 12-in. pipes, through well populated districts; Cost of labor and cartage, 0.56-ct.; material, 0.35-ct.; total, 0.91-ct. (Eight cuts were made.) Many difficult points, such as riveted tubes, bends and connections over bridges were passed in this run; in two places where pipes were laid for some distance at considerable depth, in bad ground—with bends at one point.

The cost of cleaning with hand scrapers has been as follows:

(1) 51½ miles of 3, 4, 5, 6, 7 and 9-in. pipe, in densely populated districts: Labor, 1.5 cts.; material and cartage, 0.6-ct.; total, 2.1 cts.

(2) 15 miles of 3, 4 and 5-in., under favorable circumstances: Labor, 1.27 cts.; material and cartage, 0.43-ct.; total, 1.70 cts.

Mr. W. Thwaites, M. Inst. C. E., is Engineer-in-Chief of the Melbourne & Metropolitan Board of Works, which controls the water supply of Melbourne and vicinity.

From an appendix to the paper it appears that the water supply of Melbourne is drawn from about 70,000 acres of unoccupied heavily timbered mountain land. The water is not filtered. The average daily consumption in 1901 was 35,400,000 U. S. gallons total, and about 70 U. S. gallons per capita. In 1902 there were 933 miles of 10 to 3-in. water mains, mostly 6 ins. and under, and including 174 miles of 3 in. There was also 187 miles of 48 to 12-in. mains and 76 miles of "aqueducts." The water pressure in 1902 ranged from 160 to 15 lbs. per sq. in., with 40 to 70 lbs. for the greater part of the system.

WHAT WIND PRESSURE SHOULD BE ASSUMED IN THE DESIGN OF LONG BRIDGE SPANS?*

By Theodore Cooper, M. Am. Soc. C. E.†

Mr. Turner deserves the thanks of the Profession for his investigation of the wreck of the St. Paul bridge. His explanation of the failure appears to be the probable one. For many years the writer has watched the reports of tornadoes and their effects, and has yet to find a case of a properly designed and constructed bridge which has been destroyed by the wind.

While many bridges, roofs and other structures have been overturned or destroyed by the wind, the writer has not found one case which indicated that the modern requirements for wind bracing have proved inefficient. In numerous cases, the wind has been made the cloak to cover the ignorance, inexperience, neglect or chicanery of the designer or builder. The wind has been very much maligned, and, in the writer's opinion, its power has been very much overestimated.

While preparing the Erie Specifications, in 1879, the writer found a memorandum, by the late George S. Morison, Past-President, Am. Soc. C. E., formerly Principal Assistant Engineer, giving the sizes of lateral rods in such spans as were acting stiffly under the trains. Using this as a guide, and also finding that it corresponded very closely with the results of 30 lbs. per sq. ft. of exposed surface, a lateral force per linear foot of span was adopted for "wind and vibration."

A few years ago it was brought to the writer's attention that, under modern train loads and speeds, this rule did not give sufficient rigidity, and in his later specifications it has been increased one-third.

This amount of lateral stiffness, therefore, is needed in bridges of ordinary lengths of span, regardless of the wind, and, as it has proved satisfactory under the wind forces also, there is no reason for changing it, except it be found desirable to give increased stiffness under moving loads.

All authorities agree that an absolutely steady wind is unknown; that the wind is a series of eddies and gusts; that the records of anemometers are only the measures of the highest gusts upon small areas and only represent an instantaneous and limited effect. It follows naturally that on larger areas the average pressure at any moment will be less than that recorded by the pressure gage. At the Forth Bridge the pressure on a surface of 20 by 15 ft. was practically only about two-thirds of that shown on a gage having an area of 1½ sq. ft. For larger spaces the reduction would probably be still more marked. The irregular waves of a field of grain acted upon by the wind make clear to an observer the effects of the gusts and why on large spaces the full effect is never possible at any one instant.

Since Smeaton's time a wind of 100 miles per hour has been rated as one that would uproot trees and move buildings. Such a wind, according to accepted formulas, would exert a minimum pressure of 40 lbs. per sq. ft. on small areas. A pressure of 25 lbs. per sq. ft. acting at the same moment on large areas would, in the writer's opinion, denude a district of trees and buildings, and it is very unlikely that a wind of 100 miles' velocity exerts a force greater than this on objects of ordinary size.

General Greeley, of the United States Signal Service, in 1890, after the Louisville, Ky., tornado, stated:

As bearing upon the strength of structures necessary to withstand tornadic winds, it is important to note that there have been very few cases recorded of wind velocities in the United States where the pressure of the wind, according to the latest investigations and accepted formulas, exceeded 16 lbs. to the square foot.

The severest effects of the wind occur in the paths of tornadoes. These, however, are very limited in their breadths, the high pressures or destructive effects being limited to a few hundred feet, and then the results are usually recognized as being due to the oscillation of the path of a single vortex or of a series of vortices following one another. It is probable that the destructive action of a single vortex does not exceed a breadth of about 60 ft., as has been frequently observed. Moreover, being

*A discussion (read Dec., 1904, before the Am. Soc. C. E.) of a paper by Mr. C. A. P. Turner, M. Am. Soc. C. E., printed in the Proceedings Am. Soc. C. E., Nov., 1904, and reprinted in Engineering News, Dec. 1, 1904.

†68 Broad St., New York.

a rotating force, it could not exert its pressure in any one direction for more than half its breadth.

The estimated pressures or velocities to produce the greatest recorded results, such as lifting locomotives, breaking off the top of an obelisk, twisting iron bars, driving straws through pine boards, etc., amount to only about 150 lbs. per sq. ft. or 200 miles per hour.

Julius Baier, M. Am. Soc. C. E., in his excellent paper on the last St. Louis tornado,* found evidences of pressures as high as 60 lbs. over a length of 180 ft.

At the St. Charles Bridge, the late C. Shaler Smith, M. Am. Soc. C. E., reported a tornado which exerted a pressure of 52 lbs. on small objects on the bridge and 84 lbs. in the vicinity, and which did not injure the bridge, although its bracing was only proportioned for 30 lbs. per sq. ft. of exposed surface. He also found, after following up the paths of several tornadoes, but one case where 60 ft. of width was not enough to cover the path within which the computed pressures exceeded 30 lbs.

Many careful investigators of the effects of high winds and tornadoes have concluded that it is very improbable if they ever exert an effect of 30 lbs. per sq. ft. over a space of 150 to 200 ft. at one time.

When one considers then the lateral force for which bridges have been designed and the limiting strains allowed for all bracing, one has a right to expect that any properly designed and constructed bridge will escape injurious effects from high winds or tornadoes. However strong the bridges may be braced, if they are not properly anchored down or stayed against being shoved off their seats—two very common faults—they may at some time fail.

Regardless of the very strong probability that a lateral force equal to the ordinary requirements of our specifications is never exerted by the highest winds on spans of more than 150 ft. and not oftener than once in a generation on shorter spans, the bracing due to such requirements could not be reduced without rendering these bridges inefficient against the vibrations of moving loads. But an era of very long spans has been entered, in which it is desirable and necessary to take a broader view of this subject.

To design a 2,000 to 3,000-ft. span, which the writer believes will not be an uncommon length for the next generation of bridge builders, and may even occur as a case for some of the present generation, under the same wind requirements as for spans of 500 ft. and less, would be very unscientific and wasteful.

The development of these longer spans and the limitation of the greatest possible span depend very largely upon the assumed wind force. The wind force, being practically a horizontal force, while the dead and live loads are vertical forces, any unnecessary material added for impossible wind forces is a detriment to the structure and a handicap against progress.

Sir Benjamin Baker gives the following resultant stresses per square inch, on the top and bottom members of the Forth Bridge for dead, live and wind forces, in tons:

	Dead load.	Live load.	Wind.	Total.
Top member	4.4	2	1.1	7.5
Bottom member	2.8	1.2	3.5	7.5

Bearing in mind that an important part of the dead load was due to the material added for the wind stresses, it will be seen that in the lower members the wind exerted a greater influence than the dead and live loads together.

The Board of Trade required the Forth Bridge to be built to resist a "wind force of 56 lbs. per sq. ft., striking the whole or any part of the bridge at any angle upon an area equivalent to twice the plane surface of the front girders, with a reduction of 50% in case of tubes."

Fifty-six pounds per square foot of surface striking simultaneously a length of 1,700 ft., when the highest possible claim that could reasonably be made from the evidences of the worst known storms would not give this pressure over 200 ft.!

It may be unnecessary to say that this requirement was imposed upon the eminent engineers of this bridge, and was not the result of their own conclusions.

It might be possible that a wind force of 56 lbs. per sq. ft., covering a lateral extension of 1,700 ft., through its oscillatory movements, could occur, but, from all the evidence of the character and action of such high winds, it is impossible to conceive of such a wind striking a simultaneous blow of this force over 100 ft. of lateral distance.

The absurd requirement forced upon the Forth Bridge should not be accepted as a precedent. It is time that a more rational requirement for long spans should be attempted.

For spans up to about 500 ft. the existing requirement of a fixed lateral force per foot of span should not be relaxed, as it is desirable to have this much rigidity against the action of moving loads.

For very long spans, where the exposed surfaces become much larger, the lateral force sufficient to give rigidity under moving loads may not be enough to provide for possible wind forces.

For all spans exceeding 500 ft. in length the writer would suggest the following wind forces as sufficient to cover all cases:

First—A wind force of 50 lbs. per sq. ft. acting at the same moment over a width of 60 ft., striking any part of the bridge at any angle within 30° above or below the horizontal;

Second—Similarly, a wind force of 30 lbs. over a width of 600 ft.;

Third—Similarly, a wind force of 15 lbs. over a width of 2,000 ft.; the maximum stresses from either of these requirements to be used for proportioning each member.

As all these requirements are far beyond what recorded evidence would lead us to believe as probable; as their duration, should they occur, is for a very short time, acting on a mass of great inertia; and as their recurrence would only be at long intervals of time, engineers would be justified in using high unit strains for the combined dead, live and wind loads. Assuming that for very long spans two-thirds of the elastic limit of the material for dead and live loads combined is not exceeded, they could use safely 33⅓% more, or eight-ninths of the elastic limit for the dead, live and wind strains combined, for the truss members.

Though the foregoing wind requirements, in the writer's opinion, are excessive, they are so much more reasonable than the usual ones specified for long-span bridge projects that it is desirable to have them discussed.

Their acceptance, after such modifications as may be developed by discussion, would vastly improve the possibilities of future long-span bridges.

*"Wind Pressure in the St. Louis Tornado with Special Reference to the Necessity of Wind Bracing for High Buildings." "Transactions," Am. Soc. C. E., Vol. XXXVII, p. 221.

THE PROPOSED EAST AND WEST TRANSCONTINENTAL RAILWAY IN AUSTRALIA.

When the Australian Colonies were united in a federation four years ago, it was arranged that a transcontinental railway should be built to connect West Australia with its sister colonies on the opposite side of the continent, and negotiations with reference to that enterprise have been carried on at intervals between the different colonies ever since. A gap of 1,600 miles now exists between Kalgoorlie, in West Australia, and Port Augusta, in South Australia; and the proposed railway would close this gap. While a large part of the line would pass through an arid desert, it is claimed that other sections have good grazing and some other sections are more or less timbered. The knowledge concerning the country to be covered is only that gained by explorers as the region is practically uninhabited. A survey of the line is estimated to cost $100,000 and is likely soon to be provided for by the Australian Commonwealth.

A report on the project was presented to the Australian State Department on July 27, 1903, by the following engineers representing the several colonies: H. Deane, Chairman, New South Wales; Wm. Pagan, Queensland; Alex. B. Moncrieff, South Australia; M. E. Kernot, Victoria, and C. S. R. Palmer, West Australia. The following summary gives the principal conclusion of their report:

1. We estimate the probable expenditure in construction at £4,559,000.
2. The probable revenue which may be depended upon after construction is, in our opinion, £205,860. If the past progress in Western Australia is maintained so that the present population becomes doubled in ten years after completion, the revenue may also be taken as double, viz., £411,720.
3. The probable annual expenditure in working and maintaining the line immediately after construction we estimate at £114,400, which, added to interest on the cost of construction, at 3½ per cent., £159,566, gives £273,966 for the total expenditure. After ten years, under the conditions stated, the working expenses may be taken as £210,000, and, in view of the necessary expenditure in improving works in the meantime, the interest on the enlarged capital will be £183,501, making a total of £393,501.
4. The route selected, taking all circumstances into consideration, is that via Tarcoola.
5. We have, after careful consideration of the whole question, no hesitation in stating that the standard gage of 4 ft. 8½ ins. should be adopted.
6. The time that we consider should be allowed for the completion of the line is four years.

This estimate is based on an average estimated cost for construction of £3,575 ($17,360) per mile of main line. In this estimate the great bulk of the expenses is in the track alone (about £2,300,000 representing the estimated cost of rails, fastenings, ties, ballast and track-laying). Grading is estimated to cost only £280 ($1,360) per mile. Of course in the absence of detailed surveys of the line, these estimates are only tentative, and a survey may show larger expenditures for grading to be necessary.

While the enterprise is admittedly not an attractive one, so far as prospects of direct pecuniary returns are concerned, it is being strongly urged by the prosperous colony of West Australia on the grounds of national expediency and necessity, and there seem good prospects that actual construction will be undertaken in the near future.

As illustrating the size of the Australian continent, it may be noted that when this east and west transcontinental railway is built and two short gaps of 50 and 100 miles in Queensland are closed, it will be possible for a traveler to make a continuous railway journey of 4,830 miles, from Fremantle, West Australia, to Towersvill Queensland.

MAP OF AUSTRALIA, SHOWING PROPOSED COMPLETION OF EAST AND WEST TRANSCONTINENTAL RAILWAY.

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The defiance of municipal authorities and of public opinion shown during the past two years by the men who control the gas and electric lighting companies of Greater New York is having the results which were foreseen by all thinking persons not blinded by self interest; that is, both the public and the city officials are moving rapidly towards municipal ownership of plants to light the city streets, and as a logical sequence private as well as public lighting is being given serious consideration. On Dec. 30 Mayor McClellan and the Board of Estimate of New York City followed their praiseworthy act of renewing the Burr-Hering-Freeman commission on additional water supply by the appointment of a competent commission to report on a municipal electric street lighting plant. The members of the commission are Messrs. Nelson P. Lewis, M. Am. Soc. C. E., Chief Engineer of the Board of Estimate and Apportionment; Prof. Geo. F. Sever, M. Am. Inst. E. E., of Columbia University, and Cary T. Hutchinson, M. Am. Inst. E. E., Consulting Electrical Engineer, 56 Pine St., New York City. Mr. Hutchinson made a report on this same general subject nineteen months ago, under Mayor Low's administration, and as Mr. Lewis held his present position under that administration the work of the commission just appointed will be a virtual continuation of that begun under Mayor Low.*

In his annual message, delivered Jan. 2, 1905, Mayor McClellan gives municipal lighting a prominent place. It is reported that bills authorizing both public and private lighting by the city have been introduced in the legislature.

*See Eng. News, March 19, 1903, for reports by Col. Robert G. Monroe, Commissioner of Water, Gas and Electricity, and C. F. Lacombe, Engineer of Surface Construction, under Colonel Monroe, for reasons against awarding the 1903 street lighting contracts to the combination of lighting interests and arguments in favor of a municipal plant; Eng. News, April 23, 1903, for a defense of the 1903 bids, made in behalf of the Consolidated Gas Co., and Colonel Monroe's reply thereto; May 28, 1903, for Mr. Hutchinson's report, with estimates, on a municipal lighting plant for New York City. Editorial comments on the discussion appeared in our issues of March 19 and April 16, 1903.

Second only in interest to the movement for municipal ownership of electric lighting facilities in New York City is the rider to the resolution appointing the commission instructing the latter to confer with Major Woodbury, Commissioner of Street Cleaning, on the possibilities of obtaining power from city refuse. While we have serious doubts as to the practicability of such a plan, we heartily endorse the proposition to have its possibilities studied, and we hope that as searching an investigation as is practicable will be made. In Great Britain, as many of our readers know, scores of refuse destructors are combined with electric light and railway stations, sewage and water-works pumping plants. A half-dozen companies, some with many years, and all with some, experience in constructing combined refuse destructors and power plants, stand ready to contract for the erection of more such plants of almost any size. Why cannot we do the same in America? We have long led and taught the British in the production of electric light and power and we are certainly not behind them in the design, construction and operation of steam-raising plants. But where in the United States shall one go to see a municipal refuse destructor that generates heat enough from garbage, ashes and other wastes to burn the refuse fed to it, say nothing of generating steam? That we have done so little in developing furnaces for burning mixed refuse is no proof that we cannot do as well or better than has been done abroad. The facts are, as we have so often pointed out, the municipalities of the United States have not yet treated refuse disposal as an engineering question. Consequently it would be highly advantageous for New York and the country at large if a study of the subject could be made by the commission.

We wonder if any among our older readers will recollect an editorial published in this journal seven years ago (Dec. 30, 1897), in which was discussed the question whether fog would be a hindrance to the operation of trains in the tunnel of the New York Rapid Transit Ry.

At that time a fight was being waged in New York City between the friends and enemies of the projected underground railway. Several heavy fogs caused serious delays in the elevated railway service and the lines of suburban travel, and the "Post" mildly remarked that "it probably occurred to more than one of the belated passengers that the fog could not, in the case of an underground road, play such havoc with the time of busy people."

This chance remark attracted the attention of the New York "Sun" and the "Railroad Gazette," both of which journals were at that time opposing the Rapid Transit enterprise, and they waxed facetious over the ignorance of the "Post" editor who supposed that the fog conditions would be any better in the tunnel than outside. They asked him how he proposed to keep the fog out of the tunnel and some very wise members of the engineering profession wrote to the "Post" editor and explained to him how very much worse a fog might be in a tunnel than on the surface!

In our editorial above referred to, after reviewing the contentions of the various parties as above, we gave some reasons for believing that fog would not be present in the tunnel of an underground road, even when it was thick in the streets above. We printed also a letter from the Chief Engineer of the Boston Subway, showing that up to that time that subway had been free from fog when the city itself was wrapped in it.

And now for the reason why we have rehearsed this bit of ancient history: On Tuesday, Dec. 27, New York City was enveloped in the worst fog that has been known for years. No ocean or coasting steamers entered or left the harbor for a whole day. Even the Sound steamers remained tied up at their piers. Suburban trains were greatly hampered in their movements, and so were the trains on the elevated railways. Passengers descending from the street to the subway platforms, however, emerged from a fog into a clear atmosphere. There was no sign of fog in the subway, and every one took it quite as a matter of course that it should be absent there.

In our editorial of seven years ago we concluded by saying:

> We believe that not a few of the arguments which have served to prejudice many influential men against the Rapid Transit enterprise would be found on careful and unprejudiced investigation to be like the one we have just dissected—founded on fog.

The success of the Rapid Transit system and the valuable service which it is daily rendering to the community prove that our belief in it was as well-founded as was our claim that it would not be obstructed by fogs.

We discussed in our last issue the argument against the block system made by Mr. Slason Thompson before the Western Railway Club of Chicago at its December meeting. It happened that almost at the same time that Mr. Thompson presented his paper at Chicago, the New York Railroad Club was listening to a paper in which a masterly arraignment was made of the train dispatcher system of train movement and its inherent danger was vividly portrayed. We print the substance of this paper in this issue, as it gives on the whole the best explanation of the increasing frequency of collisions on American railways that we have anywhere seen.

The author's strong plea for the train staff system is also well worth careful attention. It has long been the belief of signal engineers that this system ought to be far more widely used on American single-track roads.

The weight of metal in bridge trusses increases approximately as the square of the span. The weight of metal in the top and bottom laterals, doubtless increases as some higher power than the square of the span, for example, as the cube of the span, provided the same maximum unit wind pressure is assumed in the calculation of stresses. Thus, for a span of 2,000 ft. the steel in the laterals may weigh 1,000 times as much as the steel in the laterals of a 200-ft. span. We do not give the 1,000 (= 10^3) as an exact ratio, but merely as a tangible figure to impress the importance of careful consideration of unit wind pressures in long span bridges. Mr. Theodore Cooper, elsewhere in this issue, calls attention to the waste of metal in the laterals of long span bridges due to the use of high unit wind pressures—pressures such as have never been measured except over small areas, and he recommends a very marked reduction in the assumed unit wind pressures on bridges of long spans. It is greatly to be regretted that the data upon which to base any argument on wind pressures are so meager. With the exception of the oft cited experiments on large areas (15 × 20 ft.) at the Forth Bridge we have practically no accurate data on wind pressures upon large areas. But the so-called large area of 15 × 20 ft. is itself insignificant, although it was found to show unit wind pressures far less than on small dynamometers. After all, it may be asked, can we hope ever to measure the wind pressure upon bridges of any considerable span, and must we not content ourselves by reasoning from the observed effects of great wind storms, noting the widths of devastation and recording the pressure upon single, small dynamometers within the area of greatest action? It occurs to us that with dynamometers made to record wind pressures continuously upon paper moved by clockwork, it may be possible to ascertain with accuracy what is the total wind pressure upon any large structure. Thus, on the Forth Bridge itself, if recording wind gages were placed along both top and bottom chords at intervals of, say, 50 ft., all readings would be marked at the same instant of time, upon the record sheets, giving data far more reliable and of a kind more valuable than any number of records made upon such so-called large areas as 15 × 20 ft.

LUMP-SUM VS. UNIT-PRICE BIDDING.

A noticeable feature in the bids received for the New York Barge Canal work, which were recorded in our issue of Dec. 22, was the rarity of lump-sum bids. Contractors were at liberty to submit either itemized bids or lump-sum bids, or both; but, with few exceptions, they chose to bid by items. This fact has been seized upon

by some as indicating the desirability of awarding contracts to lump-sum bidders only; for, it is argued, the contractor who bids by items has an excellent chance to receive a final payment much greater than the total estimate at the time of letting the contract. In proof of this the old Erie Canal contracts are cited, also the contract for the New York Subway. The latter, it is claimed, is an excellent example of the advantage of lump-sum bidding.

Now, as a matter of fact, neither the old Erie Canal contracts nor the recent Subway contract prove the advisability of lump-sum bidding. In reasoning, the greatest errors often arise from attempts to generalize from one or two particular examples. The public, which has unfortunately suffered from the errors made by engineers in estimating the cost of great public works, has come to regard with suspicion all engineers' estimates regardless of the ability of the engineers, the character of the estimate or the time devoted to making it. When, therefore, they see a great piece of work carried through at a cost not greater than the original estimate they institute comparisons between this exceptional piece of work and the others that have preceded it. Knowing little or nothing about the engineers or their respective methods of making estimates, they reason about those self-evident features of the contracts under which the work was done. Finding that a lump-sum bidding price in the Subway contract and itemized bidding prices in the old Erie contracts, the inference is made that lump-sum bidding bars out all chances for extra payments, and is, therefore, the secret of successful performance of the work at a cost within the engineer's original estimate.

Such reasoning obviously ignores the other features of specifications, class of work, methods of estimating the cost, etc. In a word, the reasoning is fallacious, as can be readily shown even to those not familiar with engineering problems.

Let us enumerate the principal items that are found in nearly all final estimates which exceed preliminary estimates. They are: (1) Increased quantities of items originally underestimated as to quantity; (2) new items not found in the original estimate; and (3) increased prices allowed (a) because of the passage of laws shortening the hours of labor, or (b) because of deceptive conditions set forth in the original plans, specifications, earth borings, etc.

With the exception of item (3a)—increased prices due to the passage of labor laws subsequent to the letting of the contract—every one of these causes is directly chargeable either to incomplete engineering study of the original conditions and plans, or to a decision altering, in whole or in part, the original project. Thus, if the engineer lacks time, money, foresight or ability, he may make a hurried survey of the work, and perhaps no survey at all of the subsurface materials. In such a case the actual work is quite certain to disclose things not looked for, thus necessitating changes in plans, generally leading to increased cost. Changes of plans arising from the whims of owners, to which architects are so commonly subjected, seldom serve as excuses for engineers whose preliminary cost estimates prove to have been too low. In passing we may say, however, that the public which is quite familiar with the bills of "extras" rendered by builders of houses, and with the proverbial excess of cost of architectural work over the original estimate, is quite apt to think that engineering work is of the same feather. But to any one who has made a study of engineer's preliminary estimates and the final cost of the structures, it is at once apparent that changes of plans resulting in increased cost have almost invariably been forced upon the engineer, not by the whim of some one who holds the purse, but as the result of his own ignorance of the conditions to be encountered, and occasionally because of his own ignorance of how to design structures to meet known conditions. This ignorance of conditions does not necessarily imply lack of ability on the part of the engineer, for he may be, and usually is, capable of ascertaining what the conditions are if given time and money enough for making a thorough survey.

Coming back to the Nine-million Erie Canal work and the New York Subway, an engineer familiar with the methods of making the original estimates for each sees at once that itemized bidding and lump-sum bidding were mere incidents in the performance of these two different classes of contracts. The essential difference between the two lies in the methods of making the original estimates. Before the Nine-million appropriation was made for the Erie Canal deepening, two engineers were asked to submit to the Legislature separate estimates of cost of the proposed work, and it has been repeatedly stated—but never denied—that less than two weeks' time was allowed in which to submit the "estimates" to the Legislature. One "estimate," made by an ex-State Engineer, was nine million dollars, the other, by the then State Engineer, was twelve million dollars. The Legislature adopted the lower guess of the two, and, ever since, the nine-million "estimate" has been held up as another shining example of the inability of engineers to estimate costs with accuracy. We see that in this case there was really no survey at all—simply a guess based upon a two-weeks' "study" of assumed conditions that were afterward found to be grossly in error. We are not excusing the author of the guess, nor would we revive a dead issue except that its ghost still haunts every great public project in the State of New York.

On the other hand, we have the New York Subway as an excellent example of how to make an estimate of cost worthy of the name estimate. Numerous borings were made along the whole route of the proposed road, and local conditions were examined with the greatest care by a large corps of engineers under competent leadership. Study was made of the actual cost of subway work in Boston, and of all classes of excavation in New York City itself. Upon these data an estimate was made, and we do not hesitate to say that had the work been divided into sections of moderate length, let by itemized bidding, the final cost of the work would have been even less than it was. Why? Because the completeness of the original estimate and of the adequacy of the plans based upon it. Had the survey been less thorough, or the study of the problems made in haste, no lump-sum bidding would have saved the day. Moreover, it should be remembered that the one firm which bid upon the Subway contract, was bidding not merely for work but for a 50-year franchise. Had contracts been let after inadequate surveys, innumerable bills for "extras" and lawsuits based upon deceptive borings would probably have resulted, following the history of both public and private contracts of magnitude where subsurface surveys have been omitted or hastily made. Bills for "extras" are as just when made under a lump-sum contract as any other, and have always been allowed by the courts where it could be proved that plans were changed or where the data furnished by the engineers were grossly deceptive. The lump-sum contract possesses just one important advantageous feature, it reduces, if it does not wholly eliminate, any claims for extra compensation based upon erroneous classification of the excavated material. The same result, however, can be accomplished in other ways, where it is deemed desirable.

Why do contractors show a preference for itemized bidding? And why would itemized bidding result in lower prices in the long run? The answers to these queries may be summarized in a list of objections to the lump-sum method of bidding, as follows:

1. To the contractor the requirement of a lump-sum bid appears on its face to be a confession of haste or carelessness in making the surveys and plans.

2. The contractor knows that in the course of a few days or weeks he cannot hope to check all the surveys made by the engineers, which may have taken months or years, and he resents the attempt to make him responsible for the accuracy of the engineering work. He is very apt, therefore, to add a good percentage for insurance against what appear to him to be risks, covering also the costs of possible law suits.

3. The contractor hesitates to bid upon work where there is uncertainty as to the amounts that he will receive on monthly estimates. Lump-sum bidding, where there is a multitude of items, leaves the size of the monthly payment almost entirely to the judgment of the engineer. On public work of magnitude there is great likelihood that the engineer who is in charge at the beginning will not be in charge at the end of the work.

4. By virtue of the foregoing, contractors of long experience on public works may not bid at all, or, if they do bid, are apt to bid so high as not to secure the work.

5. Lump-sum bidding gives no basis for payment for extra work due to increased quantities resulting from changes of grade, alinement, or designs. If the engineer's allowances for such extra work are not satisfactory, the burden of the proof in case of a law suit is upon the contractor. This, as well as the cost of a law suit, is a serious objection to the lump-sum bid, in the eyes of the contractor.

6. If extra work is done on force-account plus a percentage for profit, the contractor will have no objection, but, in view of the decreased efficiency of men on force-account work, the cost will be excessive.

7. Public work done either by force-account or under a subsidiary agreement between the engineer and the contractor, often leads to charges of collusion and fraud even where there is no foundation in fact for such charges.

8. Lump-sum bidding, for reasons above enumerated, is apt to limit the competition to those local firms who know the engineers and the conditions of the work better than outside firms do. In a word, it scares away many responsible firms.

9. Finally, lump-sum bidding does not disclose what experienced contractors consider to be fair unit prices, thus perpetuating engineers' errors in estimating unit prices.

In the long run this would prove one of the most serious objections to the lump-sum method.

We see that there are many serious objections to lump-sum bidding, and that most of them are founded on the assumption that the character of the work actually done will differ from the character of the work as predicted. Now, if it turns out that the character of the work actually done does not differ from the predicted character, there is absolutely no argument left in favor of lump-sum bidding, although we still have left several arguments against it; for should there be no change of route, grade, or plans, and should the materials excavated be exactly of the kind and quantity in the engineer's original quantity sheet, there can be no "extra work," no unbalanced bids, no law suits, whether the contract be by lump-sum or by unit prices. On the other hand, should changes in or additions to the original plans be made, a lump-sum contract cannot save the municipality, state or government from ultimate payment of the additional cost—usually with the cost of legal expenses in addition.

In closing we may say that engineers should not seek to escape from the results of errors in their estimates of cost by attempting to put the burden upon the contractors. But they should stand firmly by their best judgment, always demanding time and money sufficient to make such surveys and studies of the engineering problems as will enable them to make accurate estimates of quantities and costs. Then, let them not hesitate to assume full responsibility for their estimates, seeking neither to excuse any error nor to saddle it upon the backs of contractors by lump-sum bidding requirements coupled with contract clauses that are often so one-sided and unjust as to make contracting almost synonymous with gambling.

SHALL WE HAVE FEDERAL CONTROL OF RAILWAY RATES?

Of all the governmental problems which are receiving attention at the present session of Congress, there is none so serious and none which is attracting such universal public attention as the problem of corporations and their control, and particularly the control of the great corporations engaged in railway transportation.

At the opening of this session of Congress, President Roosevelt in his annual message advocated in strong terms the Federal supervision of railway rates. Emphasis has since been added to this recommendation by the report of the Interstate Commerce Commission and its graphic statement

of the evils which are now rampant and which the commission is powerless to remedy.

Another factor in arousing public opinion on the subject is the lurid exposé by Mr. Thos. W. Lawson of the seamy side of present-day corporation finance. Hundreds of thousands of investors are reading Mr. Lawson's articles and wondering how far our great corporations are operated for the benefit of those who own their stocks and bonds and how far for the benefit of those personally engaged in their management. Now comes the report of Hon. Jas. R. Garfield, head of the Federal Bureau of Corporations, declaring that "the majority of the great corporations formed during the past two or three years have been formed for stock jobbing purposes rather than for legitimate business reasons." Stocks went down when Mr. Garfield's report was made public, not because such reforms as he advocated would injure the honestly managed corporation and the holders of its stock; but because such plain speaking tends to make even speculators distrustful, and wary of investing their funds where they may be administered with recklessness and dishonesty.

What Congress will do with the difficult problem remains to be seen. It may mark time throughout the remainder of the short session, and turn over the whole matter to the succeeding Congress; but if it pursues this course, it will do it in defiance of a strong public sentiment that calls for at least a first step toward solving the problem without farther delay or excuse.

No one at all familiar with current thought and sentiment can fail to recognize a growing enmity to the great corporations commonly called trusts, —a dread of their power and a wish to see them checked. Wherever and whenever the great mass of the people has a chance to express its opinion on this subject, there is no doubt at all on which side the opinion will be. The "man in the street," as the English call him, may not be versed in financial or economic theories, but he is "agin the trusts" every time. Nor is it alone this class of men that is dissatisfied with existing conditions. The rank and file of intelligent business and professional men throughout the country, with a more thorough understanding of the situation than "the man in the street," and a greater appreciation of the difficulties in the way of action, are no less firmly of the opinion that action of some sort should be taken. Doubtless no attempt will be made in the two months remaining of the present Congress to undertake any comprehensive action on the trust question, such as is outlined in Commissioner Garfield's report; but there *is* time to act upon the warning in President Roosevelt's message:

"*The Government must in increasing degree supervise and regulate the working of the railways engaged in interstate commerce.*"

"*Such supervision is the only alternative to an increase of the present evils on the one hand or a still more radical policy on the other.*"

It may not appear at first how close and intimate is the connection between the Federal control of railway rates and Federal control of trusts; but there are many who can testify that if the railways cannot be prevented from discriminating in favor of the trusts, then those who are trying to do an independent business may as well close down their works and let the sheriff sell their property at once.

In cases recently brought before the Interstate Commerce Commission, it was shown that by division of rates between a terminal railroad line and a through line excessive discrimination is going on. The Harvesting Machinery trust, for example, received from the railroad companies about $12 per car for switching service at its McCormick works near Chicago, which had previously been furnished for $1 to $3.50 per car. The United States Steel Corporation receives for switching and terminal service on a short road which it owns near Chicago a percentage of the through rate amounting to from $6 to $12 per car. It also receives 70 cts. per ton on coke shipped from Connellsville, or for hauling a trainload of 1,000 to 1,500 tons about 7 miles it is paid by the other railways $700 to $1,000.

It needs no argument to show that such preferences in freight rates make fair competition impossible. They are a fraud upon the competing shipper as well as upon the stockholder in the regular railway company, but there is no law in the land to prevent them. The Interstate Commerce Commission can make investigations and order the practice stopped, but it has no power to prescribe a rate, and the railway company and the trust can comply with the letter of the order by reducing the rates a single cent, and in effect snap their fingers in the face of justice.

To say that such practices breed wholesale dishonesty and contempt for law is to put it very mildly. What sort of an education is it for railway officials to find the financial powers above them attempting to conduct the property not in the interest of the stockholders but for the benefit of favored shippers and in harmony with the phases of the stock market. Will not such dishonesty at the top breed dishonesty all down the line?

But it is not alone to regulate such abuses that Federal regulation of railway rates is demanded. The Constitution declares that no man may be deprived of life, liberty or property without due process of law; but it is within the power of many railway officers to cause large losses to the property owners of communities, towns and cities, merely by their control over the freight rates enjoyed by competing commercial centers. We make no wholesale charges of dishonesty or discrimination on the part of railway officials. Often they have done their best to adjust impartially and honestly the rates between competing cities. But their best has too often resulted in an inequitable and unfair ruling and not seldom it has happened that the side which was able to bring the greatest influence to bear has triumphed regardless of considerations of equity.

Is it not time that our laws were adjusted to suit modern commercial conditions? With great labor we have established governments to protect the rights of property, courts to settle disputes over its ownership, and duly authorized bodies to equally distribute taxation.

But there sits in the railway offices a man in whose selection the electors had no choice, who can by a stroke of his pen cause the property of a thousand or ten thousand men to greatly depreciate in value, and who can so shift the transportation tax as to drive one firm into bankruptcy and lift another into affluence.

And yet we are told that any attempt to bring railway rates under Federal control is an attack upon the rights of property! The fact is that the movement in this direction is a movement to safeguard the rights of property. It is idle to ignore the existence of forces beneath the surface of our social organization that are at war with it. Repression of these forces may answer for a time, but the final result will be some sudden and radical outburst which will bring widespread ruin. The statesmanlike course is to frankly recognize the condition of public sentiment and take a forward step in accordance with it.

It should be clearly understood, moreover, that the Interstate Commerce Commission has recommended nothing at all radical. It has simply urged that the powers over rates be restored which it exercised for ten years after its establishment. The power of the railway companies to make rates would not be interfered with. All that would be done would be to make effective that supervisory power over rates which Congress intended to grant to the Commission when it was created, in 1887, and which it exercised—under narrow limitations—until it was shorn of any real power by a Supreme Court decision in 1897.

It may indeed be urged that such a reform will fall far short of the reasonable expectations of the people and that some more effective check upon the arbitrary rulings of rate-fixing officials ought to be furnished. If Congress sees fit to initiate such action, well and good; but if not, it ought at least to take a first step toward Federal supervision of railways by enacting the legislation asked for by the Interstate Commerce Commission.

LETTERS TO THE EDITOR.

What is the Labor Cost of Laying Yard Tracks?

Sir: I would like to hear from any of your readers who can quote records of the cost per lineal foot of laying new yard tracks, for the labor alone. No material costs should be included, nor the cost of engine service, but the entire labor involved for unloading the ties, rails, ballast, etc., and putting them all in proper place, completing the track laying and surfacing ready for service. One simple switch turnout from leader is included in each 1,000 ft. of track. I desire the cost from actual work under ordinary conditions with ordinary labor, such as is picked up for construction work, not being experienced section labor, but directed by experienced foremen.

Yours truly, Subscriber.

Washington, D. C., Dec 22, 1904.

What is the Matter with This Transit?

Sir: The following question of compass correction may be of sufficient interest to some of your readers to warrant a place, and reply, in your columns.

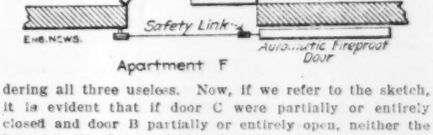
The compass bearings and vernier readings of my transit do not correspond, the error being about one degree in the quadrant, and proportionately less for smaller angles. For example, with verniers at zero and needle indicating due north, turning off 90° on the horizontal limb brings the needle to N. 89° E. instead of due east. As the needle cuts opposite points all around the circle I judge it to be straight and correctly centered, and the whole instrument is otherwise in good adjustment. Such behavior seems to indicate magnetism in some part of the transit above the lower plate. Can you or your readers suggest any other explanation, and a remedy?

Very truly, C. W. Coman.

Winnetka, Ill., Dec. 29, 1904.

The Requirement of Double Fire Doors.

Sir: Permit me to write a few words in reply to Mr. L. H. Kunhardt's letter on the "Requirements of Double Fire Doors" in your issue of Dec. 15, as I observe he has misunderstood my first letter. His explanation of the case is wholly different from that which I cited, and in order to make matters clearer I submit the accompanying plan of the doors, showing them in a position rendering all three useless. Now, if we refer to the sketch, it is evident that if door C were partially or entirely closed and door B partially or entirely open, neither the heat nor the flames from a fire originating in apartment D would attack the safety link to cause the automatic fire door to close in time to prevent the fire from entering apartment F. In fact, the fire would be well under way in both apartments before the fuse was melted at all. But if both swinging doors B and C were entirely closed, I agree with Mr. Kunhardt that both rooms would be adequately protected. Moreover, while realizing that two sets of fireproof doors form more protection than one, providing both sets work properly, I maintain that in this particular case the absence of the swinging doors would materially add to the safety of the building in question. If this could not be effected, the removal of the fuse from the end to the center of the passage should be insisted upon as a remedy.



Yours truly, W. T. Murphy.

27 Landor St., Providence, R. I., Dec. 17, 1904.

Concerning the Holding Power of Anchor-Bolts.

Sir: I have searched in vain for data from which to compute the amount of uplift an anchor bolt may be trusted to withstand when foxtailed at the bottom and sulphured into concrete, in a hole ½-in. greater in diameter than the bolt.

I will greatly appreciate information as to the adhesion per square inch of sulphur to steel or other information on the matter. "Stumped."

Duluth, Minn., Dec. 21, 1904.

(Our correspondent, by referring to the "Index to Engineering News from 1890 to 1899" will find references to this subject indexed as follows:

Anchor Bolts:

Adhesive strength of sulphur, lead and Portland cement '90, ii-53.

Anchoring Bolts in Stone '91, ii-623.

Holding Power of Anchor Bolts, Tests by M. M. Wilcox '99, ii-30.

Holding Power of Drift-Bolts '90, ii-488, 532. By F. W. Clay '94, i-25.

Experiments of U. S. Government '91, i-199; '91, ii-283.

But it occurs to us to ask the question, Why should sulphur ever be used around an anchor bolt set in stone? Why not use cement grout, which is cheaper, always available on masonry work, preserves the iron from corrosion and makes a stronger bond than sulphur. Is there any reason for sulphuring in bolts on stone except that our grandfathers used to do it before the days of Portland cement?—Ed.)

More Concerning Civil Service Examinations.

Sir: In looking over the "Letters to the Editor" in recent issues of Engineering News I was very much interested in those concerning Civil Service Examinations. If you will kindly allow me the space I would like to offer a few suggestions, having become familiar with the workings of the Civil Service from experience.

In the communication of "J. F. S." in the issue of Dec. 8 I notice that he apparently thinks that in the matter of practical experience the papers have not been fairly rated or that the candidate has exaggerated in regard to his experience. Further on he says:

> In my mind it is just such occurrences as these which discourage competent men from participating in examinations and which tend to bring the Civil Service Law into disrepute.

This complaint regarding the rating of practical experience is always heard after the eligible list is published, although not often appearing in print.

I would suggest as a remedy that the papers of all persons who pass the examinations be placed on file with the ratings for each question and experience plainly indicated, so that they might be examined by any person interested in the examination. This method I have no doubt would do away with many unjust criticisms of the ratings, both as to experience and the technical portion of the examination. At present each person who passes the examinations is notified of his standing on the eligible list, and by applying to the Civil Service Commission with his rating card he can look over his own papers, but as far as I am aware there is no means of knowing what percentage any other candidate receives for experience. The Civil Service examiners are, of course, bound to mark the papers in accordance with the experience as stated by each candidate.

When the dates for examinations are announced and the notice contains the information that some definite time, as five years' experience, is required, it is not unusual to hear the remark: "I don't know how I am going to stretch my experience to five years." It is to be feared that sometimes the candidate in his ardor stretches it up dangerously near the "elastic limit."

I presume the reason that the Civil Service Commission do not allow other papers to be examined is the fear that it would entail a large amount of extra work, and possibly bring up discussions and disputes in regard to the ratings given. I believe, however, if the ratings of the examiners were made final (re-rating allowed only in rare cases, such as for clerical errors or the like) it would not make much extra work, and I am sure would be more satisfactory to a majority of persons taking the examinations.

Another point I would call attention to is the wide range of salary covered by one examination, as in the case of topographical draftsman, transitman and computer, $1,200 to $1,800 per annum, and assistant engineer, $1,500 to $2,100 per annum. It appears to me that the salary should be definitely stated before the examination is given, as by the present method some of the objectionable features of the "unbalanced bid" are introduced, as can readily be appreciated. Respectfully,

Alfred S. Burgess.

1822 Anthony Ave., New York, Dec. 26, 1904.

A Criticism of Timber Specifications and a Suggested Method of Recording Earth Borings.

Sir: Your criticisms of ancient and ambiguous clauses in some specifications deserve commendable attention, and, it is hoped, will result in a convention of practical engineers, contractors and material men authorized to standardize all specifications. Such a convention would certainly eliminate all "gold brick" and "big stick" clauses.

There are, however, a number of clauses describing unknown materials, which vary greatly according to the specifying engineer's knowledge and experience. For example, lumber and timber should be specified according to their trade names instead of copying clauses possibly 100 years old, some pile specifications are written which can be filled neither by contractors nor by the Creator of all things.

The classification or no-classification of material to be excavated is a hard question to decide. A geological classification in many instances does not help a contractor to bid intelligently. I have known of a peculiar soft and tenacious material, overlaid by a hardpan strata, that cost more to dig, load and dump than the overlying hardpan. A piece of this hardpan would absorb water to the depth of only ¼-in. after being constantly immersed in water for two weeks. But if exposed to the air for two weeks and then immersed in water it would disintegrate into a paste.

Consequently, borings, test pits, the filing of samples and the usual records customarily submitted to contractors are often deceptive.

As this subject is being discussed with reference to public works involving excavations of great magnitude a better method of submitting the classification of material to contractors is hereby submitted. Namely, instruct the boring inspectors to enter the *time* consumed in drilling through the various strata encountered in an additional column. This would indicate a close physical classification. This is illustrated by the following records of one bore hole used as an example:

CUSTOMARY FORM.—Exhibit No. 1.
ENGINEERING DEPARTMENT.

Filing No. 108. Boring No. 8.
Location, 1'0 ft. from Sta. 320 to the right at an angle of 90°. Elevation of surface + 10 9 ft.
Began boring at 1 P. M., May 21, 1892.

Material.	Depth, ft.	Thickness, ft.	Remarks.
Black loam	1.0	1.0	
Yellow clay	10.1	9.1	
Soft blue clay	15.9	5.8	
Fine gravel	16.9	1.0	
Fine sand	23 0	6.1	
Coarse gravel	26.5	3.5	
Hard blue clay	39.6	13.1	
Boulder	41.0	1.4	Used 2 sticks of dynamite.
Hardpan	56.0	15.0	
Boulders	60 2	4.2	
Solid rock	61.0	0.8	
Total		61 0	

Finished boring at 5 P. M., May 24, 1892.
.....Inspector.

SUGGESTED FORM.—Exhibit No. 2.
ENGINEERING DEPARTMENT.

Filing No. 108. Boring No. 8.
Location, 1'0 ft. from Sta. 320 to the right at an angle of 90°. Elevation of surface, + 10.9 ft.
Began boring at 1 P. M., May 21, 1902.

Time consumed. hr.	m.	Material.	Depth, ft.	Thickness, ft.	Remarks.
0	2	Black loam	1.0	1.0	
1	0	Yellow clay	10.1	9.1	
0	30	Soft blue clay	15.9	5.8	
0	20	Fine gravel	16.9	1.0	
1	0	Fine sand	23.0	6.1	
0	50	Coarse gravel	26.5	3.5	Water-bearing, copious.
2	30	Hard blue clay	39.6	13.1	Moist.
1	0	Boulder	41.0	1.4	Used 2 sticks of dynamite.
10	10	Hardpan	56.0	15.0	Full of pebbles.
6	30	Boulders	60.2	4.2	
1	30	Solid rock	61.0	0.8	
25	22			61.0	

Finished boring at 5 P. M., May 24, 1892.
.....Inspector.

Although subsurface surveys can not be made completely and with absolute correctness within the limits of reasonable cost, the additional data in Exhibit No. 2 will not increase the cost of the present method of making the geological records of borings and test pits. It will, however, assist contractors in making more intelligent bids and may reduce the number of law suits.

Yours very truly, E. R. Shnable.

907 Security Bldg., Chicago, Ill., Dec 29, 1904.

The Engineer and the Business Man.

Sir: I presume that many of your readers, especially the younger ones, found the address of Mr. Swinburne to the students of the Institution of Electrical Engineers, published in your issue of Dec. 22 under the above caption, the most interesting page of that number. I had already greatly enjoyed the more extended extracts of the address published in a late number of "Engineering," and almost regret that you could not find place for the whole in your columns, for it was not only instructive, but possessed also a quality which such efforts generally lack, that of being amusing.

But, after all, was the tone of the speech exactly the best for the occasion, and were the ideas promulgated and particularly, was the moral drawn exactly the best to set before the class of young men to whom they were addressed? I put this interrogatively, you will note, and not assertively. Perhaps, too, any criticism of the tone, ideas, etc., are unfair when based upon the shorter extracts which you published, rather than on the whole address. I may be mistaken, but it seemed to me there was a certain tone of good humored cynicism interlining the whole, which seemed to say: "the more's the pity of it."

The title, as published in "Engineering," and which I think was the text upon which Mr. S. spoke, was "Some Difficulties in Getting On." The "getting on" meant the accumulating, or at least the winning, of wealth. Now, while the necessity, the obligation, of earning one's living cannot be too forcibly impressed upon the minds of young men such as those probably forming the majority of the class addressed, the question is whether, at the present day in England or America, it is at all necessary to stimulate the money making instincts of the generation about to enter the industrial arena.

The question raised is, should the engineer be a scientific man, or a business man, from the point of view of money making? Viewed in this aspect, there can be but one answer: a business man, every time. Indeed there is no occasion to drag the "engineer" into the proposition at all. The question would be, should the young man, whose aim in life is to make large sums of money prepare himself for the struggle by devoting himself for four years to scientific studies, or by acquiring a practical knowledge of business methods? But, as an engineer myself, I claim that if the question be put purely and simply, should the *Engineer* be a scientific or a business man? then equally there is but one answer: a scientific man, from the very definition of the name.

After all, addresses, advice, the indicating of lines of thought and springs of action which we think that young men—or old ones for that matter—should follow to fulfil certain aims, all go for naught as against temperamental bias. The young man who has the business, or administrative faculty will follow that instinct when he begins to think and act for himself, in spite of any training to the contrary which he may have received at school and which indeed he will turn to account, while the youth who feels the engineering spirit strongly within him will surely follow his star even if it does not make him a millionaire. It is the artistic faculty within him, the cravings of which must be satisfied, even if it leads only to competence and not to wealth. Any attempt to change that man into the other kind will tend to spoil a good engineer in order to make a poor business man. And note that the reciprocal of the proposition holds equally good and therefore let each man follow his star, honestly, faithfully and honorably, and each is open to achieve the kind of success he most desires. It is right, too, that each should consider his own line the best and greatest and the rewards of it, the highest.

The scientific engineer, by which term I do not mean the text-book engineer—far from it—may well be pardoned if he puts a high value on the kind of success that he most esteems. Do you recall the lines of "Punch," on the occasion of the almost simultaneous death of Stevenson and Brunel, about the year 1860?

> "A nation's pioneers; they rest. To mock
> Renown like theirs, with sculptured tomb were shame;
> Where the bridged chasm and where the pierced rock
> Proclaim mi[illegible]'s victories, read each nero-name."

E. Sherman Gould.

220 West 57th St., New York, Dec. 23, 1904.

The Engineer in the Business World.

Sir: No one who has mixed to any great extent with business men engaged in large enterprises entailing the employment of engineers can have failed to hear the expression "Oh! yes; he's a very good engineer but a d——d bad business man." Now who, or what particular set of circumstances, are responsible for the state of affairs which gives cause to this characterization? The engineers, or the business men? Both grumble, the latter as quoted, and the former at the unfeeling spirit of money-making which so often hampers them in the ideal execution of works.

Engineers, I think, too often fail to realize that the men who employ them, whose dollars they are spending, have their eyes fixed on other objects than perfection; they usually want the good-enough, and they want it as speedily as may be. The accurate engineer sets his stake with conscientious precision, often regardless of the fact that a construction crew at so much more per hour than he represents are waiting on his heels; and that usually this world being so sadly careless, it matters extremely little whether the stake is a fraction of an inch this way or that. There is a great and new realm of thought in the "good-enough" realization.

It is a fact that much, nearly all, of the art and mystery surrounding the profession of engineering have vanished during, say, the last quarter century. The consulting engineer is no longer the only man who "knows how"; a customer possessed of ordinary American horse-sense can buy so many yards of bridge to carry so many tons of load about as easily and satisfactorily as he can buy a $3.50 pair of shoes. The mail-order business covers many things.

The old cry as to the value of the college training to the engineer rises perenially; and equally strident—often more far-reaching—rises the cry of the client or employer who has hustled his unhustling engineer into one of the many half-baked works which adorn our land. This is not a matter of science in the popular acceptation of the word; it is the birth-pang, shall we say, of the new science of Goodenough. Candidly, I do not think that the great majority of engineers are good business men, but what I want to emphasize is that not only is there no reason why they should not be good business men, but that there are many, many reasons, including that of self-interest, why they should be.

They will not get a business training in colleges, for they usually are only acquiring its rudiments by contact with work, about the time they are beginning to forget what they learned of calculus. Breadth, broad grasp, broad outlook, broad knowledge, broad toleration—these are things the engineer wants and must have as competition grows keener, even if he has to dig up many cherished and laboriously cultivated precisions to get them—even the uneducated pig can dig up truffles.

And the "culture-engineer," as Matthew Arnold phrased it, looking for the highest characterization of modern intelligence, how many are there of him? The aims and results of almost any piece of engineering work are wider,

I venture to think, than the horizon of many of the engineers responsible for the design. Granted the engineer should be an idealist; he has, after all, made this world what it is to-day, for without the services of one of the family in its innumerable branches, modern civilization would be non-existant. Art, science, music, literature, surgery, where would they be? Still in the dark ages. A materialist can still be an idealist.

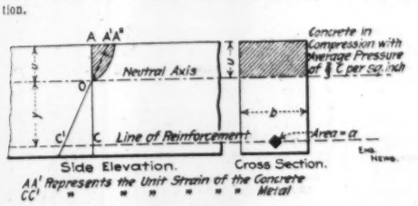
Therefore let the engineer widen out. Let him realize that from the employer's—the prime mover's—point of view he and his particular knowledge are by no means "the whole thing." Let him try, as a friend once put it, "not to have so many corns." It is a wholesome reflection for every man that the work he is doing could be done as well or better by quite a respectable number of others, even to stop and think what would have been the difference in any one particular job had he been unborn at the time of its execution. "Vicerunt fortes ante Agamemnona.

Of all men engaged in commercial pursuits the engineer should be equipped with the commercial weapons. If he disregards them, he it is who pays the piper. There is no discredit in adding to his special knowledge (shared now by thousands of his fellows and consequently decreasing in dollar-value) some of that business sense of "good-enough" which is a highly marketable asset. And then we shall hear less of engineers responsible for some million dollars' worth of work drawing therefor $200 per month while the "consulting" man, who has "only" acted as business adviser to capital, measures off his own fee. The average engineer takes life, and himself, too seriously, and that isn't business. H. J. F.

Boston, Mass., Dec. 17, 1904.

Ritter's Formula for Reinforced Concrete Beams.

Sir: The writer's attention has recently been called to the fact that one of the leading concrete engineering firms of the country is using the formulas of Prof. Ritter in the design of its reinforced beams and floor slabs. Finding the results obtained by these computations to be radically different from those of other authorities, the cause was investigated and found to lie in the primary assumption made by Prof. Ritter in the deduction of his formulas. While it is easy to condemn such an assumption it is not so easy to prove that it is erroneous, and it is therefore hoped that by presenting the subject for discussion some more light may be thrown upon the question.



Briefly then, Prof. Ritter starts out by considering that if it is desired to find the stresses introduced by a given bending moment, M, on a given cross-section, the area a of the reinforcement must be multiplied by the ratio m (the ratio of the coefficient of elasticity of the metal to the coefficient of elasticity of concrete, or $\frac{E_f}{E_c}$) and the increased area regarded as of concrete. Calculations must then be made to find the center of gravity, and the moment of inertia, of the supposed enlarged section thus obtained, thereby locating the neutral axis. This assumption is based on the following condition.

In the case of direct stress, tension or compression, where the displacement occurs, in the line of, or parallel to the line of application of the force applied, we have: if c = intensity of stress in the concrete and if f = intensity of stress in the metal then $\frac{c}{E_c} = \frac{f}{E_f}$ (since the unit strain per unit length of concrete = strain per unit length of the metal.)

whence $f = c\left(\frac{E_f}{E_c}\right)$

and the total force applied = $af = ac\left(\frac{E_f}{E_c}\right)$

Thus the quantity $\left(a\frac{E_f}{E_c}\right)$ is seen to be the equivalent area of concrete, as stated above.

Now in the case of a beam, or floor slab, when tension in the concrete is disregarded, in accordance with the requirements of the New York Building Code, and the best practice, we have:

$\frac{c}{E_c}$ not equal to $\frac{f}{E_f}$ but the following ratio holds; viz.,

$\frac{c}{E_c} : \frac{f}{E_f} = AA' : CC'$

which is at once apparent from the accompanying diagram, and since $AA' : CC' = OA : OC = u : y$

we have $\frac{c}{E_c} : \frac{f}{E_f} = u : y$

whence $f\frac{u}{E_f} = y\frac{c}{E_c}$ and $f = c\frac{y}{u}\frac{E_f}{E_c}$

Now the total compression of the concrete above the neutral axis is resisted by, and is equal to, the total tension in the metal (the tension of the concrete around the metal having been disregarded). Therefore $\frac{2}{3}c\,(u\,b) = a\,f$

and substituting the value obtained above for f

$$\frac{2}{3}c\,(u\,b) = a\left\{c\,\frac{y}{u}\,\frac{E_f}{E_c}\right\}$$

If we call the ratio $\frac{y}{u} = n$

then $c\left\{a\,n\,\frac{E_f}{E_c}\right\}$ = total tension induced.

In the above expression, by the theory of dimensions, the quantity in parenthesis is seen to be an area, and it is in fact the equivalent area desired.

n is always greater than 1 (usually it is about 2).

Hence, if we wish to find the theoretical area of concrete which would resist the total tension, in order to make use of Prof. Ritter's formulas, we must divide the expression found above by the allowable stress c, giving the expression $\left(a\,n\,\frac{E_f}{E_c}\right)$.

Comparing this with Prof. Ritter's expression $\left(n\,\frac{E_f}{E_c}\right)$ for equivalent area, we see that (a), the area of metal cross-section, must be multiplied by a factor n times (or nearly twice) the factor allowed by Prof. Ritter, and this involves us in an apparent contradiction at once.

While it may be true that in a reinforced beam, the concrete around the metal receives only 1-15 or 1-12 the stress (intensity of stress is meant, of course), it does not seem fair to say that the metal could be replaced by an area of concrete 15 or 12 times greater, acting theoretically in the same line, and still have the neutral axis retain the same position under safe loading. The foregoing calculations do not support any such conclusion, any more than does ordinary reasoning.

In conclusion, it would seem impossible to introduce conditions which apply only in the case of direct stress and strain into a problem which involves induced stresses and bending moments, and the location of a neutral axis. This conclusion is still further emphasized by the discrepancy between the location of the neutral axis by Prof. Ritter's formulas, and its location by the accepted formulas of Prof. Burr, Mr. C. F. Marsh and others. Any one who will take the trouble to work out the position of the neutral axis by the two methods for a floor slab 6 ins. thick, will find a difference of an inch or so in the result, involving thereby a difference of several thousand inch-pounds in the resisting moment computed.

Respectfully yours,

John Hawkesworth.

New York, N. Y., Dec. 8, 1904.

Concerning Various Designs of Bascule Bridges.

Sir: Referring to the "Engineering News" of Nov. 24, 1904, p. 480, we notice an article headed "Designs for Bascule Bridges Without Tail Pits." It is necessary for us to correct some of these statements made in that article in order to protect our business.

1. The writer has probably not kept track of the many bascule bridges of the Scherzer Rolling Lift bridge type constructed during the past ten years, otherwise he would know that there are many Scherzer Rolling Lift bridges in operation without tail pits, anticipating by many years the "special feature" claimed for the bascule bridge described on page 480, of which none has ever been constructed.

Among the Scherzer bridges without tail pits are the six-track New York, New Haven & Hartford R. R. bridge at Boston, Mass.; the single-track and double-track Big Four R. R. bridges at Cleveland, Ohio; the double-track bridge for the Central R. R. of New Jersey over Newark Bay; the double-track Newburgh & South Shore R. R. bridge at Cleveland, O.; the combined railroad and highway bridge for the South Eastern & Chatham Ry., across the Swale River, England, and others.

2. As to the special claim for placing the counterweight in a box and suspending it from a pin: This is nothing new. A Scherzer bridge and other bascule bridges have been constructed and counterbalanced in this manner. We have only used it for a small canal bridge, as in larger bridges there are disadvantages and additional complication, additional friction, additional wear and tear and maintenance, entirely unnecessary where the counterweight is rigidly fixed to the trusses. The method of suspending the counterweight has the disadvantage in a railroad bridge, as indicated by Fig. 1, Engineering News, page 480, of blocking the railroad traffic if it is desired to erect the bridge in the upright position and maintain railroad traffic during the construction of the bridge. It also necessitates the spreading of the trusses so as to accommodate the movement of the counterweight supports between the trusses, entirely unnecessary with the rigidly fixed counterweight of the Scherzer Rolling Lift bridge.

When the oscillating counterweight box is used, as shown in Fig. 2, page 480, for a semi-through bridge, it swings out, as indicated in that drawing, in front of the pier into the channel, and appears to necessitate the placing of the operating pinion and other parts of the machinery, as shown, in front of the pier and partly submerged in the water. This is entirely unnecessary with a semi-through or even a deck Scherzer Rolling Lift bridge without tail pits. Fig. 2, page 480, shows this semi-through trunnion bridge in the open position, which shows that, when in this position, the movable bridge leaf projects in front of the pier into the channel, necessitating a considerable longer span than is required with a Scherzer bridge, which always moves back and away from the navigable channel when it is opened. This great advantage of the Scherzer bridge has a very material bearing upon the weight and cost of the structure, and this advantage alone enables the construction of a Scherzer bridge much more economical for the same width of channel than the trunnion bridge shown.

3. The claim that the elimination of all curved structural work and track girders tends to greater economy in design, greater accuracy in shop work and greater speed in construction and erection is not well founded. Both the track girders and the circular segments of the Scherzer bridge are exceedingly simple. They are the simplest and most perfect known mechanical construction to overcome friction. This great advantage is of supreme importance in the movement of large masses, such as modern bascule bridges. With the many and complicated mechanisms shows in Figs. 1 and 2, page 480, the shop work and construction and erection must necessarily be much more expensive, less accurate and less speedy in construction and erection than the very few and simple parts comprising the Scherzer Rolling Lift bridge.

4. Fig. 1, p. 480, shows that the bracing must be omitted between the trunnion supports, as the pivoted counterweight supports move through this space. In Fig. 2 the oscillating counterweight moves in the space between the trunnion supports, and therefore the bracing must be omitted.

With the Scherzer Rolling Lift bridge all parts are rigidly braced.

5. The writer says, p. 480, "Engineering News":

"The main advantages claimed for the design are the economy due to the elimination of the tail pits (for any height of roadway above high-water), and the substitution of concrete for cast-iron in the counterweight.

Both Figs. 1 and 2, p. 480, show the roadway more than 20 ft. above the water. They also clearly show that if this height of roadway is reduced, the moving parts of the bridge will be submerged in the water if no tail pits are provided, while in the case of the double-track Scherzer bridge across Newark Bay, for the Central R. R. Co. of New Jersey, the base of rail is only 4½ ft. above high-water, yet all parts of the superstructure of the bridge are kept above high-water in both the open and closed positions of the bridge, without tail pits.

The substitution of concrete for cast-iron in the counterweight is not new. It has been used on Scherzer bridges, and is being used on Scherzer bridges where desired.

Yours very respectfully,

The Scherzer Rolling Lift Bridge Co.,

By Theo. Kandeler,

Consulting Engineer.

1616 Monadnock Block, Chicago, Ill., Nov. 28, 1904.

(Proof of the above letter was submitted to Mr. Strauss, with an invitation to make reply in the same issue. We append his letter, received in response, which has been somewhat abridged from the original with a view to eliminate all matter not strictly in the nature of a reply to the criticisms. Having thus given a fair opportunity to each party to present its case, no further space will be given to the discussion in these columns. —Ed.)

Sir: I have carefully considered the above letter, and I am free to say that I do not understand on what ground the writer deems his business interests injured by the article referred to.

It is evident to any engineer that for a high level bridge no type of bascule of reasonable span requires a tail pit, and for a low level bridge every type can dispense with these pits if economy and good design are disregarded. The only Scherzer bridges in Chicago without pits are the rather small high-level bridges at Taylor St., and at the crossing of the Metropolitan West Side Elevated R. R. The low level bridges, averaging 20 ft. clear height, all have deep pits. The 22d St. bridge, a low-level bridge now building, secures a shallow pit by means of high unbraced counterweights and elevated center of gravity. The proposed Dearborn St. low-level bridge, had no pits, but because of this had so excessive a quantity of structural and counterweight metal, that the Sanitary District was forced to reject all bids, and redesign the bridge with a pit.

The Strauss bridge is essentially a pitless bridge, and was created to eliminate the pit under all conditions with increased economy and improved design. It is capable of replacing almost every tail pit bridge in Chicago or elsewhere, with low truss structures having low center of gravity, underneath counterweight, no pits and costing from 20 to 25% less.

Similarly in overhead counterweight bridges, the Strauss bridge not only eliminates the pit, but has the advantage, first, of requiring a reduced amount of inexpensive counterweight; second, of maintaining the center of gravity near the floor line; third, of securing full counterweight bracing; fourth, of reducing the pier loads by means of the link stress; fifth, of being highly ornamental in highway bridges; sixth, of requiring the least encroachment on the land side, and, seventh, of realizing a greater total saving than the underneath counterweight type, all important factors of good design. In the Scherzer bridge the exact reverse is true. For instance, the 22d St. bridge, now building, the nearest approach to a pitless low-level Scherzer highway bridge in Chicago, with an average clear height of 19 ft., has its cast iron counterweight in four solid sections, each 3 ft. thick, 24 ft. long, and 21 ft. high, placed 16 ft. above the floor, without any transverse bracing whatever, and receiving no support from the insufficiently braced bumping girder and post. The track girder in this design is likewise unbraced throughout its length and height and the tread is on a level with the roadway floor, a decidedly dangerous practice, while the center of gravity of the structure is 18½ ft. above the floor.

The statement in paragraph 5 of Mr. Kandeler's letter, that if the head room indicated in Fig. 2 of your article of Nov. 24, 1904, is reduced, a pit would be required, is incorrect. In every Strauss design, whether of the overhead or underneath counterweight type, the length of tail end is so adjusted to the head room available as to require no pit, and the best evidence of this is that in no design has it been necessary to provide a pit, a feature of the design being that the position of the trunnion may be varied so that the effective arm for extremely low levels can be kept within reasonable limits. A case illustrating this is that of a heavy double leaf double-track railway bridge under consideration, 240 ft. c. to c. of trunnions, base of rail 12 ft. above water, in which there is neither pit, high center of gravity nor unbraced parts.

The nearest parallel case of a Scherzer bridge is the C. T. T. R. R. bridge near Taylor St., Chicago, which, with the same clear height and 275 c. to c. of bearings has a tail end construction infinitely worse than the 22d St. bridge, previously referred to, and still requires tail pits 35 ft. deep.

Paragraph 4 of Mr. Kandeler's letter, relative to the complete bracing of the Scherzer bridge is incorrect in so far as it relates to the overhead counterweight, as already noted. It is also incorrect as regards those tail pit bridges in which the counterweights enter narrow pits. Mr. Kandeler is also wrong as regards the bracing of my design, since the fixed portion which he questions is in the form of rigidly-braced towers on both sides of the moving leaf in both the overhead and underneath counterweight type, and these towers are themselves thoroughly tied together.

In paragraph 2 of Mr. Kandeler's letter, he goes astray on many points. I do not claim, for instance, that the pivoted counterweight is new. It is, in fact, almost as old as the trunnion bridge itself, and just about as old as the rolling lift bridge, a number of which were built in the early eighties in Europe. The Havre bridge of France, for example, was built in 1824, while the first Scherzer bridge was built in 1893.

The Strauss counterweight, however, is not a simple pivoted counterweight, but a parallel link mechanism and a system of counterweight construction which secures a new result, this result being a reduction of lever arm, an increase in the size of counterweight box which permits the use of concrete, and a reduction of the load on pivot pier and anchorage. The patents covering this construction have passed the General Counsel for the Western R. R. Association, as free and clear. The only bridge in which it has been possible for the Scherzer Co. to use concrete counterweight is the bridge at Marseilles, Ill., in which it has resorted to a crude application of my device, and the Scherzer Co. has recently been served with notice of infringement by my licensees, Roemheld & Gallery, engineers and contractors, Chicago.

The statement that the pivoted counterweight is disadvantageous in a large bridge because of "additional complication, additional friction, additional wear and tear and maintenance" is untrue. A similar argument was advanced against the pivot of the regular trunnion bridge, and has only been abandoned recently in face of the absolute proof that there is no appreciable wear of trunnion bridge pivots. If this is true of the main trunnions carrying both dead and live loads, it is truer still of counterweight pivots carrying only dead load. Every pivot in my design is provided with phosphor-bronze bushings and is not stressed higher than 1,400 lbs. The friction on such joints is very small in comparison with that of the main trunnions, and if there is any perceptible addition it is more than offset by the greater accuracy in the counterweight lever arm. Furthermore, in a trunnion bridge, friction is a very small element compared with wind and snow, and the plain trunnion bridge in consequence has shown itself to be the easiest moving. The same reasoning holds good with the Strauss bridge.

Nor is it true that the Scherzer Co. has used pivoted connection in small bridges only, for in the Harrison St. bridge there are 12 moving pivoted joints in its live load anchorage, all without bushings of any kind, and in the discarded Dearborn St. design there were 8, only 4 of which had bushings. All Scherzer operating struts have pin connections, and in some Scherzer locks, moving pins are used. It is evident from this that Mr. Kandeler is somewhat inconsistent, especially since he has adopted moving joints in his very latest designs, and for live loads, whereas I use them only for dead load. There is considerable complication in these Scherzer moving joints as a glance at the designs referred to will show; but if there is any in a simple pivoted counterweight box and link, it has so far failed to appear to engineers generally.

The difficulty of erection of the railroad bridge shown in Fig. 1, of your article, exists only in the imagination of Mr. Kandeler. The Strauss moving leaf is erected in the usual upright position, while the overhead counterweight box is erected in the closed position above the clearance line, subsequently moved into place and the counterweight filled in. The bridge at Cleveland, now under construction, will be erected in this way by the American Bridge Co. without interruption of either rail or water traffic and it is fair to assume that this company knows what it is doing.

Another delusion of Mr. Kandeler is the economy of the Scherzer bridge, due to the receding movement of the leaf. While this shortens the main span, it lengthens the approaches in the same ratio. Whatever saving there is from the former consideration is offset by the latter, and by the additional track girder spans needed to carry the leaf as it rolls back. The limit of clearance, furthermore, is fixed by the front end of this track girder span, and in highway bridges by the sidewalks, which break far ahead of the main support.

In deck trunnion bridges it is true that the truss projects beyond the trunnion when the bridge is open, but this disadvantage is not material in view of what has been said above, and in a through trunnion bridge it disappears altogether. In the Strauss design there is so much gain in the counterweight and in the approaches and substructure that it is not a factor in any case.

This was shown in the proposed Dearborn St. bridge previously referred to. In the Strauss design for this bridge the low truss structure shown in Fig. 2 of your article was used, and the fenders were placed 6 ft. beyond the extreme steel work, open or closed. This made the bridge somewhat longer than the Scherzer deck bridge between bearings, notwithstanding which the guaranteed estimate of the Strauss bridge showed a reduction of 200 tons of structural steel and of $20,000 in cost of counterweight, or a total reduction in cost as compared with the Scherzer design of about $40,000.

Returning for a moment to paragraph 2 of Mr. Kandeler's letter and to his belief that my machinery is submerged, Mr. Kandeler overlooks the fact that in the particular design referred to, Fig. 2 of your article, the machinery is supported on top of the pivot pier above high water and is enclosed in a concrete housing reaching to the bridge floor. Also that this machinery may be placed immediately underneath the bridge floor. Also that in this design the trusses were not spread and that in Fig. 1 where they were, it had no effect whatever in reducing the large discrepancy in cost between his own design and mine for this particular bridge. As to the defense of the curved work of the Scherzer bridge, in paragraph 3, it is only necessary to say that if this represents Mr. Kandeler's honest belief he has forgotten a good deal about practical work in a bridge shop, and if he desires a correct idea as to the cost of different types of bascule bridges it might be well for him to compare the pound prices for structural steel and erection on the straight truss Strauss bridge and on the various track girders and curved truss bridges such as the Scherzer and others.

The only correct statement made by Mr. Kandeler in his entire letter is that none of my bridges has been built, and with the completion of the Cleveland bridge in the spring, this, the only argument against the Strauss design, will be void. For the present it is sufficient to state that in open competition, the Strauss bridge, complying with every requirement of modern good practice, has shown itself in every case to cost far less under equal conditions than any other acceptable bascule bridge.

Very truly yours, J. B. Strauss,
Consulting Engineer.

805 Opera House Block, Chicago, Dec. 17, 1904.

Notes and Queries.

F. L. Getman, Resident Engineer Ithaca Water-Works, Ithaca, N. Y., wishes to know where he can find a formula or data for calculating the volume of water flowing over the edge of a vertical pipe with varying depths (h) on the edge of the pipe. Mr. Getman states that he has a few observations taken on artesian wells which he has weired, but not a large enough variation of heads (h) to derive a constant for use considering the pipe as a circular weir, which is applicable when the water sheet stands out from the sides of the pipe and does not trickle down it. Investigations for these purposes are under way in the hydraulic laboratory at Cornell University, but the results will not be obtainable before next June.

THE INSPECTION OF MATERIALS AND MACHINERY FOR THE U. S. NAVY.*

For the important work of inspecting the materials of all kinds used in the machinery of our naval vessels the Bureau has divided an extensive territory into nine districts. The Bureau has tried to keep on duty as executive head of each district a commissioned line officer of experience and good judgment, familiar with the peculiar needs and requirements of naval machinery. A naval officer, as head of each inspection district is, in the Bureau's opinion, absolutely essential to the proper conduct of Government inspection. To assist the heads of districts there are 22 civilian inspectors, carefully selected by means of competitive examinations. These assistant inspectors are divided among the districts as the quantity or importance of the work demands. In addition to the work of inspecting its own material, this Bureau's inspectors inspect material for the bureaus of Yards and Docks, Equipment, Ordnance, Supplies and Accounts, and Construction and Repair. The total number of pounds inspected and passed during the year is as follows:

For Bureau of:

Steam Engineering	29,581,237
Yards and Docks	46,482,539
Navigation	102,813
Supplies and Accounts	1,215,362
Construciton and Repair	620,676
Medicine and Surgery	50,500
Equipment	9,123,170
Ordnance	594,320
Total	87,773,617

This is an increase over last year of 44.2%.

This Bureau's work for Construction and Repair is limited to composition metals, and brass and copper pipes, as that Bureau has its own steel inspectors.

The character of the materials inspected is most varied. Among the most important are engine and gun forgings of steel; castings of iron, steel and composition metal for naval engines; boiler plates and tubes, condenser tubes and tube plates; steel steam pipes and copper and brass pipes.

The Bureau also inspects finished boilers, engines and electric motors, as well as valves, engine fittings of all kinds, power tools, gages, and instruments of precision. The finished product of main engines, boilers and auxiliaries in our warships represent the efforts of many manufacturers. The boiler plates are made by one firm, the tubes by another and such castings as are required by yet another. The same is true of the engines. The steel forgings are made by one firm, the steel castings by another, and so on through the long list of the varied articles that go to make the finished engines that drive our warships at high speed. Each and every one of these component parts of both main engines and auxiliaries must be the very best of its kind, and the Bureau's inspectors at the works of the various manufacturers must see that the requirements of the specifications are met in every particular, and that the work of inspection of the assistants is carried on properly and without friction.

The naval officer in charge of the inspection work of a district is personally interested in his work as no civilian can possibly be. His brother officers, or it may be himself, are to have the care of the complicated machinery afloat, and he knows that to the good character of the inspection will be due that freedom from breakdown in the day of trial that the country has the right to expect. When the needs of the fleet will permit, young line officers should be ordered to duty with the present able naval inspectors to learn the particulars of this most important work, so that in the future as in the past the inspection of the materials that go to make the fighting machine we call a warship shall be in the hands of those who are to use the machine and who must therefore be most vitally concerned in the excellence of its various parts.

The headquarters of the inspection districts are as follows:

Homestead Steel Works, Munhall, Pa.—One officer with six civilian assistants, one of whom has charge of the Bureau's chemical laboratory, do the inspection work of this district, which includes, in addition to the great steel works of the Carnegie Steel Co., 30 manufacturing establishments doing Government work requiring inspection.

Midvale Steel Works, Nicetown, Philadelphia, Pa.—One officer and three civilian assistants do the inspection work of this district, where 31 firms and manufacturing establishments in Philadelphia and vicinity do Government work requiring inspection. At Midvale and at Bethlehem are made nearly all the large engine forgings of nickel steel used in naval machinery.

Bethlehem Steel Company, South Bethlehem, Pa.—One officer and two civilian assistant inspectors, one of whom has charge of the Bureau's chemical laboratory, do all the inspection work of the district, which includes three firms and manufacturing establishments doing Govern-

*From the Annual Report of the Bureau of Steam Engineering, U. S. Navy.

ment work requiring inspection. The naval inspector of engineering material is also ordnance inspector.

American Steel Casting Company, Thurlow, Pa.—One officer and one civilian assistant to do the inspection work of this district. In this district are made a large proportion of the steel castings used in the engines of our warships. Many anchors for the Bureau of Equipment are made in this district and inspected by the Bureau's inspector. There are in this district six firms and manufacturing establishments doing Government work requiring inspection. The naval inspector in charge of this district is also inspector of machinery for the Navy at the works of Harlan & Hollingsworth, Wilmington, Del.

Harrisburg, Pa., room 21, post office building.—One officer and two civilian assistants do the inspection work of this district. There are in this district 15 firms and manufacturing establishments doing Government work requiring inspection.

Brooklyn, N. Y., room 5, post office building.—In this important district two officers, one on the retired list, and two civilian assistants inspect the work done for the Government by forty firms and manufacturing establishments. These places are located within a comparatively small area, so that inspection work is carried on without the great loss of time made necessary when the area to be covered by the inspectors is a large one. In this district are made many important auxiliary engines for naval vessels; the inspection of the material for these auxiliaries, as well as the inspection and test of the finished engines, must be as carefully attended to as the same work for the main engines themselves. The naval inspector of engineering material is also ordnance inspector.

District of Connecticut, with headquarters at Hartford, Conn.; works of the Colt Fire Arms Co.—One officer and one civilian assistant do the inspection work of this district. There are in this district 22 firms and manufacturing establishments doing work for the Government requiring inspection. In this district are made practically all the condenser tubes for Government vessels. The inspection of these condenser tubes is work of the greatest importance, for the Bureau recognizes that the relatively short life of these tubes is a weak point in the endurance of naval machinery. The Bureau is endeavoring in every possible way to increase the lifetime of condenser tubes, and to this end the naval inspector of material in the district is directed to cooperate with the tube makers in their endeavors to turn out a tube that shall have more lasting qualities than the ones at present obtainable. In this district a large part of the copper and brass pipe used in the Navy is made, also rolled composition material of various kinds.

District of the Middle West, headquarters at Barberton, O.; works of the Stirling Boiler Co.—One officer and three civilian assistants do the inspection work of this district. There are in the district 29 firms and manufacturing establishments doing Government work requiring inspection. At Shelby, O., in this district, are made a large proportion of the smaller-sized steel boiler tubes for the Navy. The work of this district has increased nearly 100% over what it was last year.

District of Massachusetts, with headquarters at Boston, room 45, post office building.—One officer and one civilian assistant do the inspection work of this district. There are in the district 39 firms and manufacturing establishments doing Government work requiring inspection. These places are for the most part in Boston and vicinity. In this district are made many blower engines and steam pumps for the Navy, all requiring close inspection during manufacture.

In addition to the inspection work done in the regular inspection districts mentioned above, a large amount of inspection work in the near vicinity of their stations is done by officers detailed as naval inspectors of machinery, notably in the cases of naval inspectors of machinery at the works of the Fore River Ship & Engine Co. and the Bath Iron Works. The Bureau has one civilian inspector stationed at the Fore River Ship & Engine Co.'s works.

FLUCTUATIONS IN LEVEL OF LAKE MICHIGAN.

The fluctuations in lake levels, or so-called tides, was referred to in a paper on the Chicago intercepting sewers, read by Mr. W. A. Shaw at a recent meeting of the Western Society of Engineers. A considerable stretch of the intercepting sewer on the South Side was built along the shore of Lake Michigan, partly through the water, being protected by sheet piling and a crib breakwater, and the space between the shore and the breakwater was afterwards filled in. At first only slight variations of 6 to 10 ins. in the level of the water were noticed, but on May 30, 1902, at about 7 p. m. there was a sudden rise of about 2½ ft. above the normal, causing some slight damage to the work. We quote from Mr. Shaw's paper as follows:

After this experience the sheet piling was left with the top about 3 ft. above the water level. In July, on a very hot and sultry day, we experienced unusual tide phenomena; twice during the morning the water rose to the top of the sheeting, but it receded so quickly that it did not do any damage. About 11 a. m. the lake suddenly rose to about 4 ft. above normal, flooding over the top of all sheeting and dams. The water held at this height for perhaps two minutes, washing large braces, etc., into the conduit. One out of the three temporary dams between the sheeting held, so that the damage resulting was small. Work was shut down on that day for repairs and but few men were working; otherwise it is likely that many men would have been drowned by the rush of water, as the water rose so rapidly that the men could not have been warned. There were perhaps three minutes between the low and high water. The tides on Lake Michigan are probably caused by differences in atmospheric pressure, as on the day of the high tide the Weather Bureau reported about that hour of the day a high barometer, immediately followed by a low barometer, moving from west to east. These tides were always noticed on a sultry day.

PLANS FOR NEW SUBWAYS IN NEW YORK and extensions to the present rapid transit system were presented, Dec. 29, to the Rapid Transit Commission by their chief engineer, William Barclay Parsons. The estimated cost of the work outlined for Manhattan is $40,000,000, and for Brooklyn and the Bronx $9,000,000, not including one proposed line in Brooklyn which is likely to prove so expensive that Mr. Parsons has not yet submitted an estimate of its cost. The plans contemplate in Manhattan an East Side subway from the Battery to 145th St., by way of Lexington Ave., and a West Side line from the Battery to 42d St. The West Side line would connect with the new Pennsylvania R. R. station. The plans for the Bronx provide for an extension of the present system from Kingsbridge to Van Cortlandt Park; an extension from 180th St. through Bronx Park out to the city line; and a continuation of the Eighth Ave. division of the elevated road out Jerome Ave. to Woodlawn.

For Brooklyn, a route is proposed from Manhattan over the Manhattan Bridge, and under Flatbush Ave. to Fourth Ave. and out Fourth Ave. to Fort Hamilton. An alternative route is from the Battery, where connection would be made with the present system, under the East River to Governor's Island, under Buttermilk Channel to Hamilton Ave., thence under Hamilton Ave. and Fourth Ave. to Fort Hamilton. There is also planned an extension of the present system from the Prospect Park Plaza, under the Eastern Parkway.

Pamphlets, to the number of 1,000 containing maps and descriptions of the routes, will be printed for public distribution. The contemplated work is such that others than the present owners of transportation franchises may submit bids.

A BOARD OF WATER SUPPLY FOR NEW YORK City was recommended by Mayor McClellan in his New Year's message. The proposed commission would consist of three members, all named by the Mayor, but two chosen as follows: one from a list certified by the governing body of the New York Chamber of Commerce and one from a list certified by the American Society of Civil Engineers. Bills reported as ready for introduction in the New York legislature immediately after its opening on Jan. 4 provided that each of the bodies named above should submit three names to be chosen from; that each member of the water board should be paid $12,000 a year; that the water board should report to the board of estimate and apportionment, and that the latter board should have power to adopt, amend or reject the entire plan submitted by the water board. Mayor McClellan stated in his message that the revived Burr-Hering-Freeman commission is expected to report this month on the $90,000,000 scheme recently submitted to the Board of Estimate and Apportionment by the Commissioner of Water Supply, Gas and Electricity.

A UNION DEPOT FOR BUFFALO, N. Y., has been agreed upon by the presidents of all the railways entering the city, 13 in number. The railroads agree, in a proposition to the city, to purchase the site for the station, but they ask that the city vacate certain streets, and cede the old Hamburg Canal bed and a section of the Erie Canal, soon to be abandoned, beside providing a plaza, a mall and suitable wide street approaches in front of the station. Public sentiment seems to favor granting these requests. The area selected for the station is about half a mile north of the present group of stations, and four blocks west of the junction of Main and Niagara Sts. It extends from Delaware Ave. to Carolina St., covering 1,000 × 3,000 ft. The station building will have a 400-ft. frontage. In the rear will be a covered concourse 100 ft. wide × 600 ft. long, extending over 32 depressed tracks.

In conjunction with the union station, the city plans to build steamer excursion docks, 1,200 ft. long, in the rear of the terminal and connected with it by two large viaducts. The union depot and terminals will cost the railroads $10,000,000, and the city will expend $3,000,000 besides.

Mr. Charles W. Goodyear, president of the Buffalo & Susquehanna R. R., is chairman of the Union Depot Commission, appointed by the Mayor, to confer with the railroads in selecting a site.

The railroads interested are: Delaware, Lackawanna & Western, Lehigh Valley, Erie, Pennsylvania, Buffalo, Rochester & Pittsburg, Buffalo & Susquehanna, New York Central, New York, Chicago & St. Louis, Lake Shore & Michigan Southern, Michigan Central, Grand Trunk, and Pere Marquette.

A NAPHTHA SHIP blew up at sea a few weeks ago while en route from New York to Cette, France. The vessel was the bark "Marpesia," an iron ship about 40 years old. The naphtha was carried in barrels, of which there was also a deckload. The explosion is supposed to have been caused by some of the barrels breaking loose and becoming leaky, thus filling the ship with explosive vapor. Eleven of the crew were killed. The explosion tore the ship to bits.

A WALL WAS BLOWN OVER upon an adjoining hotel building, in Minneapolis, Minn., on Dec. 20, crushing the building and killing several persons who were asleep in it. The building to which the wall belonged, located on Fifth St., was a warehouse, and extended two stories higher than the hotel building. This warehouse, and another to which it was connected by a wooden bridge, burned out on Dec. 13, 1904; the wooden joist floors were consumed and left only the walls. The side wall, 12 ins. thick, was blown over just a week later, when an exceptionally high wind, 55 miles per hour, prevailed. The coroner's jury, which investigated the accident, exonerates the building inspector, but places blame on the Common Council as follows:

> The remote cause of the deplorable casualty is, in our opinion, found in the iniquitous practice of the city council in granting special permits for the violation of the building ordinance, even in opposition to the recommendation of the building inspector. Were it not for this practice, which resulted in the construction of runways between the Boutell and Peck buildings (the two warehouses which burned), the recent fire would probably have been confined to the latter building, in which case the wall which fell would have been well-protected from the wind which blew it down. This practice of granting permits is vicious and dangerous in the extreme.

The accident aroused much public criticism, as reflected in the above extract from the coroner's findings. That local engineering sentiment favors reformed building laws appears in an interview with Mr. C. A. P. Turner, M. Am. Soc. C. E., of Minneapolis, who says:

> The walls of a building eighty or a hundred feet high are not designed to stand alone under wind pressure without the lateral support of the floor framing, hence any system of construction in which floors and frame may be readily burned out, leaving the walls without this lateral support, is evidently not only a menace to the lives of firemen in fighting a fire in such a building, but also to the property and lives of those who happen to be in the immediate vicinity.
>
> Before the art of construction reached its present state of development there was some excuse for the construction of such buildings as those destroyed; to-day there is none. Such buildings as those destroyed could be duplicated by the up-to-date engineer at little or no increase in expense, made thoroughly fireproof and of about double the strength for the same money they would cost in the wood floor, cast column and steel beam construction used.
>
> For this reason the city council should amend the present building laws, allowing no further construction of death traps, forcing owners to build modern structures and their architects to discard the Chinese conservatism which has prevented very largely the adoption by them of modern ideas and methods.

THE UNIVERSAL METER SYSTEM has been unanimously adopted in town meeting at Brookline, Mass., on recommendation of a special committee composed of James M. Codman, Jr., Desmond FitzGerald, Past-Pres. Am. Soc. C. E. and others. The system will be adopted by degrees, it appears, and at public expense, it having been decided to recommend that the next town meeting (March, 1905), appropriate $15,000 for the work. Town departments, as well as private consumers, will be metered.

VERTICAL SPRAY STREET SPRINKLERS for cleaning bitulithic pavements during wet weather in New Bedford, Mass., have been used by Mr. C. F. Lawton, Superintendent of Streets of that city. In dry weather, Mr. Lawton states, hand sweeping is satisfactory, but after a day or two of wet weather the pavement becomes coated with a slimy substance which requires flushing for its removal. Flushing with fire hose was used until quite recently, but to avoid scaring horses and hindering traffic this had to be done at night, thus adding to the cost of the process, expensive at best. The wagon used at New Bedford is made by the Eastman Co., of Concord, N. H. A few trips along the street, working from the center outwards, washes the pavement clean without the spray striking one point long enough or with force enough to break up the surface of the pavement.

A GASOLINE LOCOMOTIVE FOR TUNNEL WORK is being used in driving the 19,500-ft. tunnel for the water supply of Santa Barbara, Cal., according to the "Mining and Scientific Press." The locomotive has a 5 HP. single-cylinder gasoline engine, built by the Union Gas Engine Co., of San Francisco, Cal. The car and transmission gearing were built by the Los Angeles Engineering Co., of Los Angeles, Cal. The locomotive weighs 3,000 lbs., is 2 ft. wide, 6 ft. long and 5¾ ft. high. The height could be considerably reduced if necessary. Oil and water tanks are in the rear. It is provided with an acetylene headlight. The tunnel is now in 450 ft., and

the locomotive is not taxed to its capacity as it hauls only 2 tons of rock per load, although it has shown a drawbar pull of 600 lbs.

THE CITY OF SHEFFIELD, ENGLAND, had 237 miles of "dry" or ordinary macadam streets and 14 miles of tar macadam, out of a total of 387 miles of dedicated and undedicated streets on March 25, 1904. Other kinds of pavement, in order of length, are as follows: Granite, 42 miles; freestone, 41; boulders, 37; wood, 7; whinstone, 2 miles. The remaining eight miles of streets are classified under "Tramway Track," as follows: Wood center macadam sides, 5 miles; granite center, macadam sides, 3 miles. In this total of 387 miles of streets about 30 miles of trenches were opened during the year as follows: Electric supply committee, 17 miles; water committee, 7 miles; gas company, 4 miles; National Telephone Co., 0.8-mile; Postal-Telegraphs (Government), 0.55-mile. These figures, however, do not include trenches for services. From a list of sewers constructed during the year it appears that pipe over 12 ins. in diameter was rarely used, the list showing a few short lengths of 15-in. and everything larger having been built of brick. Rubble sewers are being replaced with brick and with pipe, but there are still 95 miles of rubble sewers in use. About twelve miles of sewer were cleaned or flushed during the year at a total cost of £2,546, which is equivalent to $12,370, or about $1,000 a mile. The methods employed are not described. Sewage to the amount of 7,798,000,000 U. S. gallons was treated during the year or an average of about 21,000,000 U. S. gallons a day. Most of this was treated by chemical precipitation with lime, but about 1,200,000 gallons a day passed through the experimental bacterial works. It has been concluded "that it is unnecessary to bring the sewage to a marked septic condition before applying it to contact beds, simple settlement, followed by contact beds, having produced results of a most satisfactory kind, without any greater deterioration of the contact beds." Based on these conclusions plans for new sewage works have been made which call for settling tanks, contact beds and storm water beds. These plans, we may add, were recently submitted to the Local Government Board for approval. Mr. Charles F. Wike, M. Inst. C. E., is city surveyor of Sheffield.

PERSONAL.

Mr. Charles Wanzer has been appointed City Engineer of Portland, Ore.

Mr. John Price has been appointed Superintendent of Streets of Jacksonville, Fla.

Mr. Emmett Smith has tendered his resignation as City Surveyor and Engineer of Bayonne, N. J.

Mr. Russell Robb has become a partner in the firm of Stone & Webster, Consulting Engineers, of Boston, Mass.

Mr. L. Eidlitz, Architect, of New York City, has formed a partnership with Mr. Donald Ross, under the firm name of Eidlitz & Ross.

Mr. E. M. Stayton, a civil engineer of Independence, Mo., has gone to the Spanish Honduras, where he will be engaged in railroad construction work.

Mr. E. F. Henderson has been appointed Resident Engineer of the Valley Division of the Atchison, Topeka & Santa Fe Ry. Co., with headquarters at Oakland, Cal.

Mr. M. B. Terrass has been appointed Resident Engineer of the Los Angeles Division of the Atchison, Topeka & Santa Fe Ry. Co., with headquarters at Los Angeles, Cal.

Mr. William Rist of Fort Collins, Colo., has been appointed Division Engineer of Irrigation District No. 1, State of Colorado, to succeed Mr. L. R. Hope, who died last summer.

Mr. R. J. Arey has been appointed Resident Engineer of the Albuquerque and Arizona Divisions, including Barstow Yard, of the Atchison, Topeka & Santa Fe Ry. Co., with headquarters at Williams, Ariz.

Mr. H. M. Scharle, of Dubuque, Ia., a civil engineer in the employ of the Illinois Central Ry., has been transferred to Clarksdale, Miss., where he will act as Assistant to Chief Engineer on all southern surveys.

Mr. H. K. Barrows, Assoc. M. Am. Soc. C. E., Engineer U. S. Geological Survey, announces that the office of the District Hydrographer for New England has been located at Rooms 808-9, No. 6 Beacon St., Boston, Mass.

Mr. J. W. Thompson has been appointed General Manager of the Southern Indiana Ry. Co., with offices at Terre Haute, Ind. The office of General Superintendent, heretofore held by Mr. Thompson, has been abolished.

Mr. C. C. Jones, Superintendent of the Middle Division of the Grand Trunk Ry., has been appointed General Manager of the Central Vermont R. R., to succeed Mr. E. H. Fitzhugh, appointed Third Vice-President of the Grand Trunk.

Professor Florian Cajori, Dean of the School of Engineering at Colorado College, has been selected as one of the eight mathematicians who are to aid in the production of a new historical work on mathematics, which is being compiled by Moritz Cantor of Germany.

Mr. William Barclay Parsons, M. Am. Soc. C. E., has been retained by the New York, Westchester & Boston Ry. Co. as Chief Consulting Engineer, and Mr. William A. Pratt, until recently Chief Engineer of the Staten Island Rapid Transit R. R., has been retained for a period of at least two years as Chief Engineer.

Mr. A. McL. Hawks has returned to his office at Tacoma, Wash., after an absence of six months at The Dalles, Ore., where he has been acting as Consulting Engineer for the Open River Association, which is assisting the state in building the Oregon State Portage Road around The Dalles from Celilo to Big Eddy.

Mr. E. S. Lea, M. Am. Soc. M. E., has resigned his position as Sales Manager for the De Laval Steam Turbine Co., and has opened an office at 42 Broadway, New York, as consulting engineer. Mr. Lea, prior to his four years' connection with the De Laval Company, had a wide experience in the designing and construction of power plants and water-works and in the manufacture of general machinery. He will make a specialty of steam turbine and centrifugal pump practice.

Mr. Nicholas Van Vracken Franchot, of Olean, N. Y., is to be appointed Superintendent of Public Works of New York State, to succeed Charles S. Boyd, according to an announcement of Governor Higgins. Mr. Franchot is 48 years old, a graduate of Union College, and has been identified with the business interests of Olean for a number of years. As Superintendent of Public Works, Mr. Franchot will have charge of the awarding of contracts incident to the $101,000,000 barge canal work. The position carries a salary of $6,000 and an allowance of $2,500 annually in lieu of expenses.

Mr. William Pierson Judson, M. Am. Soc. C. E., has resigned his position as Deputy New York State Engineer, to take effect Feb. 1. Mr. Judson, as Deputy State Engineer for three terms of two years each, in addition to many other official duties, has had general charge of the system of highway construction in New York State. The drawing of specifications for, and the making of final inspections and acceptances of more than $7,000,000 worth of macadam and gravel roads, have formed a part of the work done by Mr. Judson in his official capacity. His report to the Mayor of Oswego on the selection of pavements for that city, when printed about 12 years ago, gave Mr. Judson a standing as an authority on roads and pavements in this country which his subsequent work and writings have confirmed. Previous to the publication of the first edition of his "City Roads and Pavements," Mr. Judson had been for some years U. S. Assistant Engineer in charge of harbor work at Oswego. His measurements of wave force, by means of dynamometers, form the first records of the kind made on the Great Lakes. An article by him on subaqueous rock excavation at Oswego is the first publication, of which we have knowledge, in which the methods and costs of modern methods of drilling and blasting from scows are described.

Mr. Judson resigns now, at the beginning of a new term, because of the great increase of work which will be entailed by the provisions of the new law for highway maintenance which puts the care of all the roads in the State, both new and old, under the State Engineer, and will so increase the already arduous duties of the Deputy as to require that officer to spend practically all of his time in travelling by night and in going over roads by day. This increase of duties would prevent Mr. Judson from giving any attention whatever to his considerable private interests which are such that he decides to retire from the office of which the added duties will be more than he cares to undertake.

Obituary.

Augustus Homes Bixby, at one time a civil engineer, died at his home in Francestown, N. H., Dec. 18. He was 77 years old.

Charles G. Buscall, for 50 years an Inspector of Buildings for the Board of Education of New York, died in that city Jan. 2. He was 81 years old.

Sampson B. Oulton, a retired building contractor, died at his home at Rockaway Beach, N. Y., Dec. 25. He had built many blocks of houses in South Brooklyn, N. Y.

Isador Davidov, M. Am. Inst. Min. Engrs., died at the Hotel Margrave, New York City, Dec. 28. He was a native of Russia, in which country he was born 38 years ago, and came to this country 15 years ago. He was well known as a mining engineer in the West, Central America and Mexico.

Joseph Spenard, a civil engineer of Beauport, Que., died at Quebec, Dec. 25, from a self-inflicted pistol shot wound. A few minutes before Spenard killed himself, he had become involved in a drunken squabble in an all-night eating house, during the course of which he had shot his opponent in the breast, inflicting a dangerous wound.

James F. Secor, a former well-known shipbuilder, died at his home at Pelham Manor, N. Y., Dec. 27, aged 90 years. Mr. Secor was the builder of the Mare Island Navy Yard in San Francisco and the Pensacola Navy Yard in Florida. During the civil war he secured many contracts from the U. S. Government for building monitors, ironclads and dry docks.

William H. Baldwin, Jr., President of the Long Island R. R., died at his country home at Locust Valley, L. I., Jan. 4. He had been suffering from intestinal trouble, and little hope had been entertained for his recovery since his removal last September from the German Hospital, where two operations had been performed on him. Mr. Baldwin was born in Boston in 1863, and was graduated from Harvard University in 1885. Immediately thereafter he entered the employ of the Union Pacific, and three years later was advanced to be Division Freight Agent, and later became General Manager of the Leavenworth Division of that road. In 1890 he was appointed Vice-President of the Union Pacific system, and shortly after he became General Manager of the old Flint & Pere Marquette road. He remained in this position three years, and then accepted the Third Vice-Presidency of the Southern R. R. In 1895 he was promoted to be Second Vice-President, and in the following year was called to succeed Austin Corbin as President of the Long Island R. R.

John P. K. Otis, President and Manager of the Union Water Meter Co., died at his home, 26 Downing St., Worcester, Mass., Dec. 21, aged 51 years. John Pierce Kettell Otis was born in Worcester, March 9, 1853. He obtained his education at the grammar and high schools in Worcester and then began the study of engineering, which became his life's work. In 1869 he entered the City Engineer's office in Worcester and in 1871 attended a course at Worcester Polytechnic Institute, from which he was graduated two years later. He was then appointed Assistant Engineer for the construction of the Springfield Water-Works and after two years there was, in 1875, appointed engineer for the construction of the Portland, Me., Water-Works, a position he held until 1878. From 1878 to 1881 he was Instructor of Civil Engineering in Worcester Polytechnic Institute. In 1880 he became Manager of the Union Water Meter Co., of Worcester and in 1900 was made its President, also. Mr. Otis leaves a wife, and five children. He was a member of the Montacute Lodge A. F. & A. M., Worcester Board of Trade, Worcester Society of Engineers, Society of Antiquity, Commonwealth Club and Worcester Mechanics Association.

ENGINEERING SOCIETIES.

COMING MEETINGS.

MICHIGAN ENGINEERING SOCIETY.
Jan. 11 to 13, 1905. Annual meeting at Lansing, Mich. Secy., F. Hodgman, Climax, Mich.

AMERICAN INSTITUTE OF ARCHITECTS.
Jan. 11 to 13, 1905. Annual meeting at Washington, D. C. Secy., Glenn Brown, Washington, D. C.

INDIANA ENGINEERING SOCIETY.
Jan. 12 to 14, 1905. Annual meeting at Indianapolis. Secy., C. C. Brown, Commercial Club Bldg., Indianapolis, Ind.

OHIO SOCIETY OF SURVEYORS AND CIVIL ENGINEERS.
Jan. 23 to 25, 1905. Annual meeting at Columbus, O. Secy., E. Q. Bradbury, Columbus, O.

WOOD PRESERVERS' ASSOCIATION.
Jan. 16 to 19, 1905. First annual meeting at New Orleans, La. Secy., C. W. Berry, Laramie, Wyo.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 18 to 20, 1905. Annual meeting at Chicago, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 24 to 26, 1905. Annual meeting at Montreal, P. Q. Secy., Prof. C. H. McLeod, 877 Dorchester St., Montreal, P. Q.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Jan. 30 to Feb. 11, 1905. Annual meeting at Birmingham, Ala.

ASSOCIATION OF ONTARIO LAND SURVEYORS.
Feb. 28, 1905. Annual meeting at Toronto, Ont. Secy., Killaly Gamble, Temple Bldg., Toronto.

IOWA ENGINEERING SOCIETY.
Jan. 11-to 13, 1905. Annual meeting at Iowa City. Secy., Arthur J. Cox, Iowa City, Iowa.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Jan. 11, 1905. Annual meeting at Boston, Mass. Secy., Willard Kent, Narragansett Pier, R. I.

BROOKLYN ENGINEERS' CLUB.—The next meeting of the club will be held at the club rooms, 197 Montague St., Brooklyn, N. Y., on Thursday evening, Jan. 12, when Mr. W. T. Donnelly, will read a paper on "Floating Dry Dock Construction," which will be illustrated by lantern views.

NEW ENGLAND WATER-WORKS ASSOCIATION.—The annual meeting of this association will be held at Hotel Brunswick, Copley Square, Boston, on Wednesday, Jan. 11, 1905. The headquarters in Tremont Temple will be open for the use of members at 10 a. m. Lunch will be served at Hotel Brunswick at 1 p. m. The meeting will be called at 2 p. m. Besides the routine annual business, there will be a paper, illustrated with lantern views, on "The Manila Water Supply," by Mr. Desmond FitzGerald.

ENGINEERS' CLUB OF PHILADELPHIA.—A regular meeting of the club will be held on Saturday, Jan. 7, at 8.15 p. m. Mr. F. H. von Keller will present a paper on "Principles and Applications of Mercury Vapor Apparatus."

The following nominations have been made for officers: For President, Mr. Silas G. Comfort; for Vice-President, Messrs. Jos. B. King and Geo. Neville Leiper; for Secretary, Mr. Walter Loring Webb; for Treasurer, Mr. Geo. T. Gwilliam; for Directors, Messrs. W. P. Dallett, Jno. T. Loomis, and Henry H. Quimby.